WAREHOUSE AND PRESERVATION METHODS AND ECONOMICS FOR STORING MATERIEL

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by

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OBJECT OF TASK

To determine the type of environment and preservation level best suited for long term storage of materiel under the Bureau of Yards and Docks technical cognizance as to effectiveness, efficiency, and economy.

ABSTRACT

NCEL is conducting a five year storage test program to evaluate various storage environments and preservation levels for materiel under the Bureau of Yards and Docks technical cognizance.

Similar paired items of military equipment were stored in different storage environments - an open air slab, a shed, a standard warehouse, a 40% RH warehouse, and a 50% RH warehouse. One of each pair had light domestic preservation treatment and the other full contact preservation treatment. Deterioration was permitted to develop at its natural rate in each environment. Periodic inspections were used to determine the storage protection afforded by each environment.

Results of 2-1/2 years of storage show that protection is poor in open air, fair in the shed, good in the standard warehouse, and better in the RH warehouses. These results parallel those obtained from Corrosometer readings taken periodically at each environment. Compared to domestic treatment, contact preservation decreases rust incidence about 58% for open air and 50% for shed and standard warehouse. Warehousing costs were determined for each environment. Under environmental conditions similar to those of the test, it is usually cheaper to store in the 50% RH warehouse, but the standard one is cheaper for automotive and non-metal equipment. It is cheaper to protect equipment stored for stateside use with domestic treatment, but contact preservation is cheaper for overseas use. After 2-1/2 more years of testing, all items will be completely disassembled for final storage evaluation.

The Navy standard 40-ft x 100-ft prefabricated metal building appears generally satisfactory for advanced-base dehumidified warehousing, but it has too many joints to be easily sealed.

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INTRODUCTION

After World War II, the Department of Defense inaugurated a war-readiness program against possible future military action. This program set aside large quantities of war materiel for mobilization reserves and peace-time preparedness use. At times some of this equipment is replenished with new stock. The Prevention of Deterioration Center, Washington, D.C. estimated the DOD materials and equipment in storage to be worth 51 billion dollars in 1957.

To maintain this materiel in a usable condition, the military became warehousemen and experts in equipment preservation and inspection. However, such storage and preservation is expensive. The Construction Battalion Center, Port Hueneme, California estimated its direct annual storage cost to be about 1.5 percent of the acquisition value of their stores. If this 1.5 percent is applied to the 51 billion dollars mentioned above the taxpayer must pay over 3/4 billion dollars a year.

Corrosion is the most costly deterioration of equipment in storage. The primary factors contributing to it are oxygen and alternate wetting and drying; sunlight and variable weather are secondary. Oxygen is continuously present, while the wetting and drying comes largely from night-time condensation and day-time evaporation. Condensation in areas with high dew-point temperatures may be visible as a film or drops of water. In dry climates, it may be an invisible microscopically thin film. Temperature stability, the partial pressure of the water vapor in the air, and the mass-area ratio of the object all influence the amount of condensation. Corrosion accelerates if condensation includes dissolved mineral salts such as those present in ocean air and certain industrial atmospheres. Dust particles settling on the metal from the air also accelerate corrosion markedly.

Corrosion of ferrous metal shows as rust which forms in speckles, in areas, and in pits. Each form has a special effect on the problem of restoring the surface. In some instances rust will grow out from a spot and cover a large portion of the surface. In other cases the spot will not spread in areas but will work into the surface forming a pit. There are also times when the spot will grow in area as well as in depth. As rust on any critical surface will hamper the equipment when it is put to use, rust must be either prevented or removed.

PART A - EFFICACY OF STORAGE ENVIRONMENTS

BuDocks has direct responsibility for design, erection, and maintenance of all Navy land-based storage facilities and is involved in much of the stores acquisition for these facilities. In the interest of increasing storage effectiveness and reducing costs, BuDocks initiated a program at the Naval Civil Engineering Laboratory, Port Hueneme, California between July 1955 and January 1956 under Task NY450 010-8, presently Y-F015-04-004. Tests are scheduled for 5 years and this report covers the results of the first 2-1/2 years testing.

Some of the items in the NCEL test were unprotected and received the full brunt of oxygen, wetting, drying, and corrosion accelerators such as sea air and dust. Since the most serious type of corrosion is rusting, insofar as this task is concerned, rusting is the only type of corrosion considered. Rusting can be studied in terms of temperature, partial pressure of the water vapor, exposure samples, and corrosion indicators (which are described in this report). From detailed periodic inspections the extent and effect of rust can be studied and evaluated using rusting indices, rust area count, and rehabilitation costs.

In the NCEL test, the rehabilitation costs are computed from inspection records of materiel which has been permitted to deteriorate unchecked. These costs will be different from those experienced in the field, for current practice requires deterioration to be corrected when discovered, and cost is computed for work and materials involved in restoration and representation. The field method insures a high degree of readiness for shipping (statistically 96% acceptability). Had deterioration been corrected when discovered in the NCEL test, no useful data could have been obtained since rust removal and representation would have been synonymous to starting tests anew.

The Laboratory results cannot be directly compared with field practice without additional study, because, while repair of a defect at time of inspection will increase handling costs, immediate repairs can decrease over-all maintenance costs by eliminating major rehabilitation costs. This is especially true for domestically stored items in open-air, shed, and possibly standard warehouses.

DESCRIPTIONS AND METHODS OF TEST

a. Storage Environments

The military uses four basic types of storage environments. These are open-air, shed, standard warehouses, and controlled humidity warehouses. Open-air storage exposes equipment to the rigors of weather. Shed structures, though not complete buildings, provide considerably more protection than open-air, particularly during periods of bad weather. Standard warehouses, widely used commercially, are complete structures, and except for outside air infiltration, completely protect goods from the elements. Controlled humidity warehouses, also complete structures, protect not only from the elements, but reduce the effects of moist air infiltration by controlling the moisture content of the warehouse air. NCEL tested these four types of environments including two levels of controlled humidity warehouses to make a total of five environments.

The open-air storage unit consists of a 40-ft x 100-ft asphaltic concrete floor slab 4 in. thick which is bounded by a Portland cement curb level with the floor slab. The shed, standard, and controlled humidity warehouses are 40-ft x 100-ft prefabricated metal enclosures whose floors are 4-in.-thick asphaltic concrete. The shed is a partially complete building without its leeward side (along the length). The standard warehouse is a complete building and was erected as received from stock except that it was lined with 1-in. glass fiber insulation and hard-pressed fiberboard on interior walls and ceiling. Building panels are 2 ft x 4 ft. Interior insulation was installed for the purpose of dampening the daily temperature fluctuations within the warehouses. The controlled humidity warehouses were erected similarly to the standard one including insulation, but had all joints sealed by caulking with a bituminous cut-back cement, windows and rear cargo doors replaced with regular metal siding, and front cargo doors sealed after stores were set in place. Access is through gasketed personnel doors cut in each front cargo door. A 200-cfm dual-bed silica-gel dehumidifying machine, installed in each of the two controlled humidity warehouses, automatically maintains the relative humidity at 40% in one and 50% in the other. Figure 1 is an aerial view of the five storage conditions.

b. Materiel in Storage

The equipment for the test was selected from the Naval Construction Battalion stocks. Selected were such items as jeeps, dump-trucks, searchlights, steam boilers, pumps, welders, bake ovens, lathes, and telephone switchboards. The 5 types of storage environments were stocked with similar equipment except that certain types not normally stored in open air or shed were omitted from them. The open-air and shed environments each contain 19 different items and the remaining environments each contain 29 different items. Figure 2 shows the placement of items in a warehouse. Appendix A gives a complete listing of all items in the test.

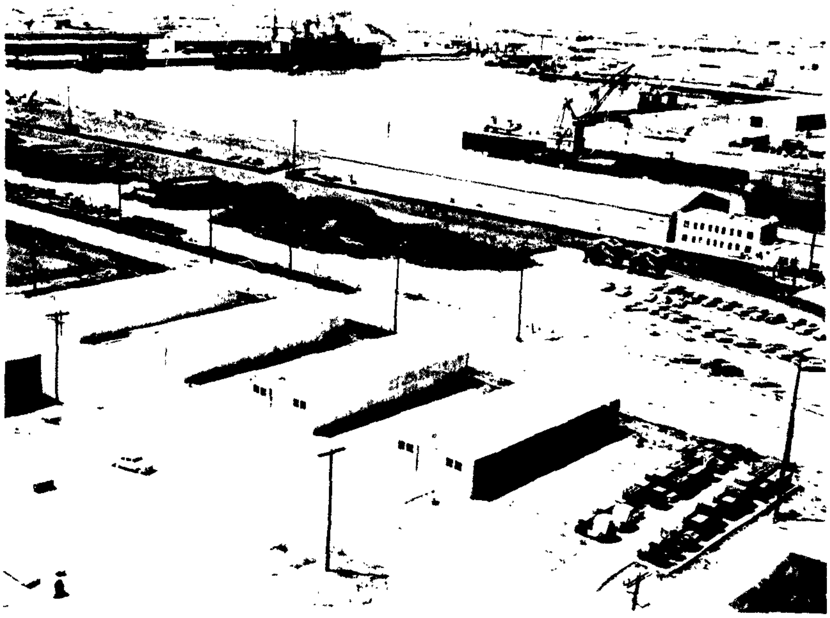


Figure 1. Aerial view of the test storage environments. From left, 40% RH, 50% RH, Standard, Shed, and Open Air.

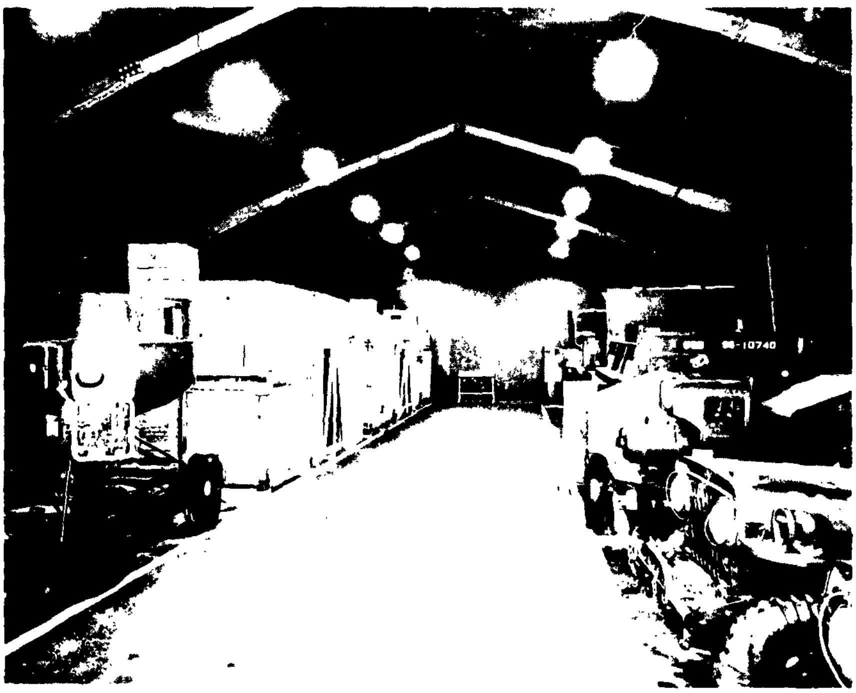


Figure 2. Interior of the 50% warehouse. Stock arrangement as shown is identical in all environments.

c. Preparation of Materiel for Storage

Preparation entailed disassembly of all items, cleaning, inspecting, repairing, photographing, and preserving. As each item was placed in "as new" or A-1 condition it was photographed.

Preparing the stores for the test was scheduled so that as each environment was erected, immediate stocking could begin. Stocking began with the open air, continuing through the period from July 1955 to February 1956, and was completed with the 40% RH warehouse.

The items are stored in pairs for the purpose of studying two levels of protective coatings. One unit of the pair is protected by "domestic" treatment and its mate by "contact" preservation. Domestic treatment is a cursory treatment performed by the supplier or manufacturer. It consists of applying P-1 preservatives* to exterior non-machined ferrous metal surfaces and placing regular in-service oils and greases in the transmission, differentials, and other working areas of the equipment. It also includes retouching paint and taping shut any openings which might admit moisture. Contact preservation is a very thorough treatment and is performed by the Navy. It consists of a range of P-type preservatives applied to all corrodable exterior and interior surfaces, exterior surfaces repainted where necessary, openings sealed to exclude moisture and airborne water vapor, and packaging and packing according to NavDocks instructions TP-PW-14.

d. Inspection of Materiel

Materiel is inspected periodically to determine the ability of each environment to protect equipment from rust, and to provide a basis for calculating rehabilitation costs. Equipment in the open air is inspected every 3 months, in the shed every 6 months, and in the remaining three environments every 12 months. This is known as "sequential testing" and is frequently used in scientific work. This method has the advantage that a decision may be reached with fewer test samples than needed for non-sequential testing.

These inspections entail a partial disassembly of equipment. For example, inspection of automotive equipment involves the removal of various cover plates, wheels, crankcase pans, cylinder heads, etc. The inspections conform with the instructions of the Quality Control Procedures manual TP-QC-1 for class II inspections.

*P-1 is a corrosion-preventive compound (light oil) which dries to a thin, hard film following application.

Upon completion of the 5-year exposure period, all equipment will be given a final inspection. This inspection will consist of a complete disassembly and will conform to the TP-QC-1 manual for a class III inspection. A class III inspection, as described by the manual, is "a complete tear-down to conduct a minute examination of a complex equipment item." Undoubtedly the final inspection will reveal many areas of rust undetectable by a class II inspection.

Rust and deterioration encountered during each inspection is classed, recorded, and representative areas photographed. Classification is in accordance with the Bureau of Yards and Docks uniform terminology, class I, II, III, or IV, as follows:

Class I - Stain Discoloration or staining with no evidence of pitting, etching, or other surface damage visible to the naked eye.

Class II - Light Corrosion Surface corrosion. Loose rust or corrosion. No tight rust or scale. When removed by wiping, leaves a stain but no evidence of pitting, etching or other surface damage visible to the naked eye.

Class III - Medium Corrosion Loose or granular rust or corrosion, together with visible evidence of minor pitting or etching.

Class IV - Heavy Corrosion Powdered scale, or light rust or corrosion together with deep pits, or irregular areas of material removed from the surface.

Although direction to the Construction Battalion Centers to use this terminology was issued about 2-1/2 years after the start of the test, the inspection records permitted easy conversion to the new system of classification.

e. Instrumentation

Instruments measuring the corrosion-producing potential of each environment are the Corrosometer and motorized wet and dry bulb temperature recorders.

The Corrosometer, manufactured by the Crest Instrument Co., Santa Fe Springs, California, consists of a probe(s) and special meter. The probe is essentially a taut metal sensing element 4 mils in diameter and 3 inches long which is connected electrically to the meter during readings. The extent of probe corrosion is determined by measuring the changes in electrical resistance as its cross-section is reduced. A steel, an aluminum, and a copper probe were placed in each of the five storage environments. The meter consists of a modified Kelvin Bridge circuit which measures the corrosion penetration into the wire and converts this measurement to micro inches of penetration. Corrosometer readings were made periodically. Since the resistance measurements are average resistance of the wire elements, this method is analogous to measuring weight changes of metal coupons.

Psychrometric data is obtained and recorded for all environments by Minneapolis-Honeywell wet-and-dry-bulb motorized psychrometers. In the controlled humidity warehouses, an electronic controller automatically maintains the relative humidity at the desired level. The controlled humidity warehouses are each equipped with two dew-point recorders, a wattmeter, and a timer. Charts are changed weekly and temperatures averaged with a polar planimeter for the seven-day period. Figure 3 shows much of this instrumentation.

For the controlled humidity warehouses, air infiltration through unintentional openings, such as cracks and loose seals, is estimated by pressurizing the buildings and determining the exfiltration. A 500-cfm centrifugal fan which draws in outside air was installed in each dehumidified warehouse. From a known rate of air drawn in and the resultant warehouse air pressure, determined by two inclined manometers, infiltration and the relative tightness of the building can be determined. Pressurization also indicates whether the joint sealing compound is remaining supple or is hardening.

f. Rusting Index

When making periodic inspections, the class of rust and percent coverage is recorded. Only surfaces involved in equipment operation are considered. Rusted surfaces are assigned weighted numbers which permit the rust to be included as an integral factor. Arbitrary numbers are assigned to the four classes of rust mentioned above and to the percent coverage. As the percent coverage can only be estimated, accuracy is not sacrificed by reducing the rust coverage to four categories. The four categories of coverage and four classes of rust are assigned the numbers as follows:

Class of Rust	Percent Area Rusted	0-25	26-50	51-75	76-100
	Weight	1/4	1/2	3/4	1
I	1	1/4	1/2	3/4	1
II	2	1/2	1	1-1/2	2
III	3	3/4	1-1/2	2-1/4	3
IV	4	1	2	3	4

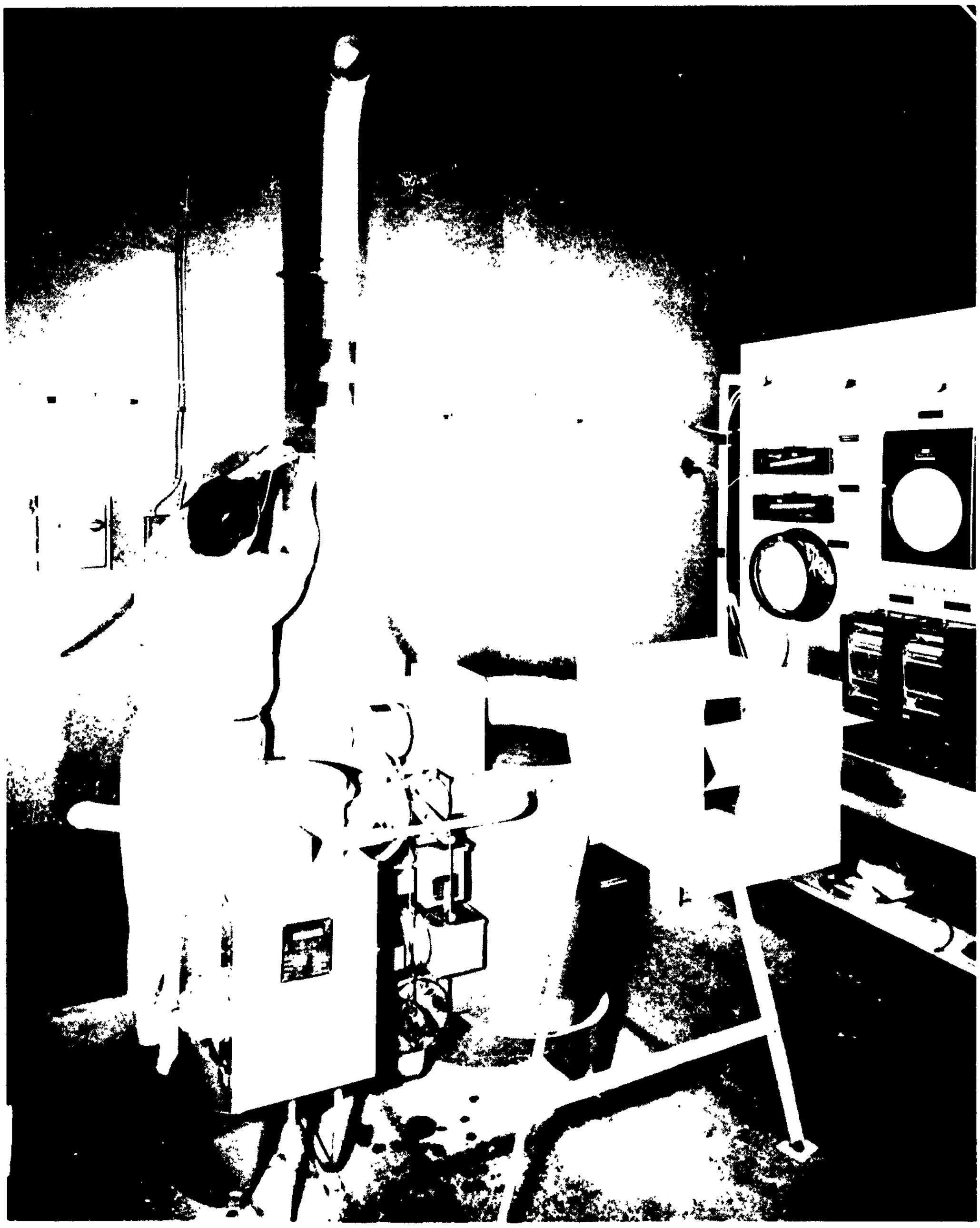


Figure 3. Equipment and instrumentation in the 50% warehouse. Desiccant machine is in the foreground.

The weighted numbers are rusting indices for any given surface. To determine the rusting index, the number corresponding to the class of rust is multiplied by the number corresponding to the percent coverage of rust. This procedure is carried out for all critical working surfaces of the item and the indices are then summed. The sum is the rusting index for the item of materiel, and indicates the seriousness of rust quantitatively. For example, an item could have one surface with 30 percent coverage of class II rust and another with 90 percent coverage of class III rust. The seriousness of rust would then be determined as follows:

$$\begin{array}{l} 1\ (2 \times 0.5) \\ 3\ (3 \times 1.0) \\ \hline 4 \text{ Rusting index} \end{array}$$

The rusting index is used to obtain rehabilitation costs for periods of less than 30 months. It is assumed that rehabilitation costs are proportional timewise to the magnitude of the rust count curves for the appropriate environment and preservation condition.

The rusting index has its limitations in that if severe rusting is encountered, the man-hours for rehabilitation will not increase as rapidly as the rusting index. A leveling-off point will be reached in the rehabilitation cost when rusting reaches the point that major disassembly for restoration is necessary.

g. Rust Count Curves

Rust count curves are plotted with the number of critical rust areas as the ordinate and time as the abscissa. The first point on each curve represents the initial inspection; 3 months for open air, 6 months for the shed, and 12 months for the standard and dehumidified warehouses. Succeeding points represent each periodic inspection. After 30 months of storage, enough points were established to clearly define the trend of rusting for all similarly treated items in each environment; the trend of each curve is extrapolated to zero deterioration in order to estimate the occurrence of initial rusting. These curves present an over-all indication of storage efficacy because the number of critical rust areas plotted for any one inspection represents the sum total of all areas of all equipment for each preservation condition. Rust on a surface critical to operation or use of the equipment is counted, while rust on a non-critical surface is not counted. The rust count curves do not take into consideration the seriousness of rust, as is done in the afore described "rusting index."

h. Rehabilitation Cost

The open air items were removed from the test after 30 months of exposure to prevent permanent damage to domestic-treated equipment, and because most of the contact-preserved equipment critically needed representation. This equipment was given a class III inspection and minutely examined. From the records of this inspection, a detailed analysis was made by the Production Control Division of CED who then estimated rehabilitation costs.

TEST RESULTS

The results presented in this part of the report concern only the storage protection of the various environments. Results concerning storage costs are given in Part B.

a. Corrosometer Readings

A resume of corrosometer readings are given in Table 1. Curves based on the table are shown in Figures 4, 5, and 6. The July 1, 1957 readings are from new uncorroded probes at zero exposure time with "tare" values deducted. These initial tare readings were deducted so that the table and curves originated with zero corrosion.

The set of curves in Figure 4 are for steel probes. They show a marked difference between rusting rates in the open air and the shed, and those in the standard and dehumidified warehouses. It is surprising how close the standard warehouse curve is to that of the dehumidified warehouses. The data from the 50% RH and 40% RH warehouses is so nearly the same that it is impossible to separate the curves.

Figure 5 shows the set of curves resulting from the exposure of copper probes. These probes corroded considerably less than the steel ones in the open air and shed, and about the same for the three remaining warehouses. Interestingly, although only a small amount of corrosion occurred in the 40 and 50% RH warehouses, even less developed in the standard one.

Table 1. Corrosometer Readings[1]

Date	Probe Type	Open Air	Corrosion Shed	Penetration - Mils Standard	50% RH	40% RH
July 1, 1957	Steel	.000	.000	.000	.000	.000
	Copper	.000	.000	.000	.000	.000
	Aluminum	.000	.000	.000	.000	.000
Aug 19, 1957	Steel	1.326	.230	.014	.000	.004
	Copper	.032	.012	.018	.022	.038
	Aluminum	.064	.000	.006	.030	.008
Sept 30, 1957	Steel	[2]	.450	.028	.032	.020
	Copper	.098	.030	.036	.026	.040
	Aluminum	.176	.022	.046	.036	.024
Oct 30, 1957	Steel	[2]	.542	.018	.016	.010
	Copper	.092	.018	.014	.034	.020
	Aluminum	.196	.030	.000	.022	.020
Dec 1, 1957	Steel	[2]	.634	.036	.042	.016
	Copper	.138	.044	.042	.060	.046
	Aluminum	.262	.070	.014	.058	.034
Feb 8, 1958	Steel	[2]	.860	.032	.020	.020
	Copper	.166	.054	.040	.054	.044
	Aluminum	.460	.100	.040	.048	.044
Mar 11, 1958	Steel	[3]	1.056	.038	.028	.024
	Copper	.208	.058	.024	.052	.044
	Aluminum	.583	.080	.034	.044	.038
May 29, 1958	Steel	[3]	1.460	.040	.032	.028
	Copper	.250	.094	.026	.036	.028
	Aluminum	.780	.160	.018	.052	.058

1. Readings converted from micro inches to mils.
2. Indicator off Corrosometer scale.
3. Probe completely rusted in two.

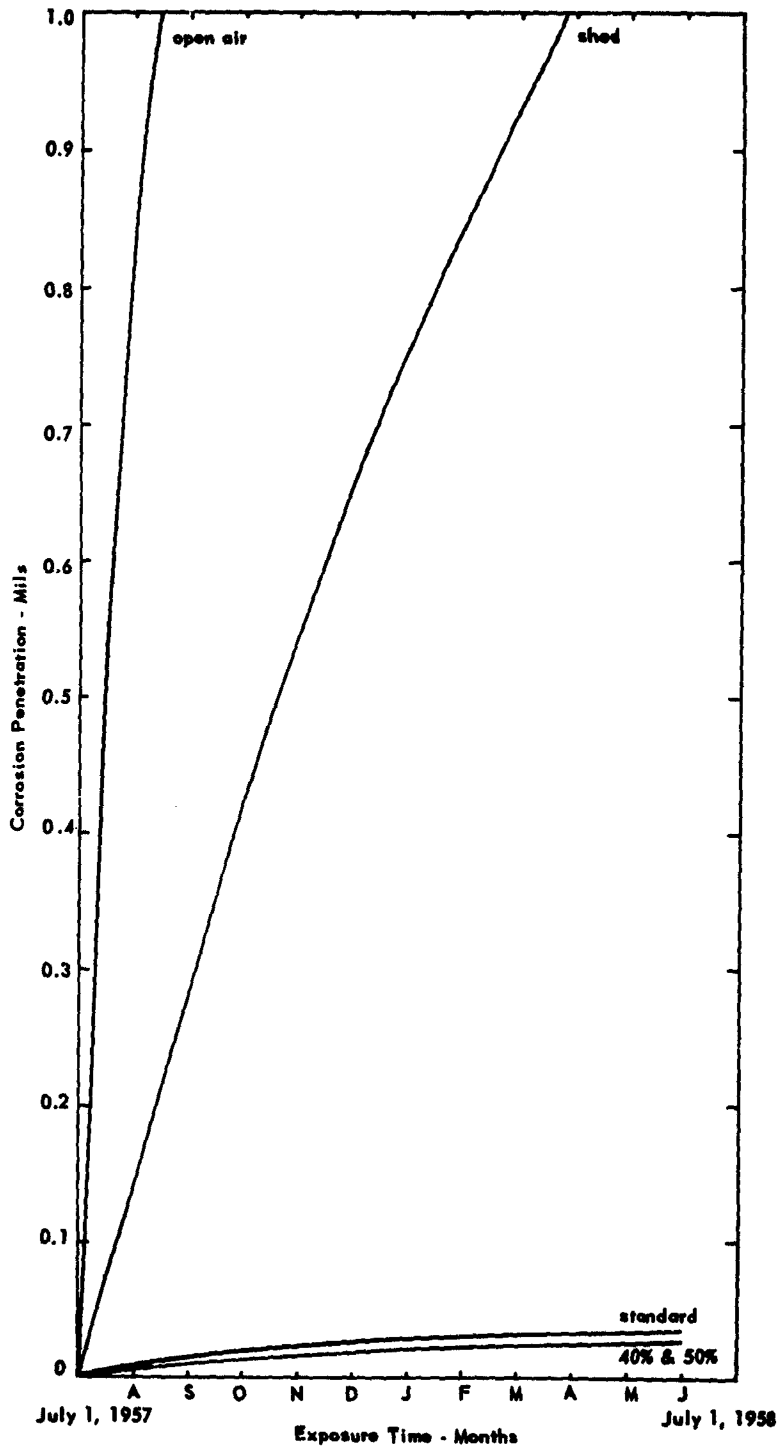


Figure 4. Curve Set for Corrosometer Steel Probes

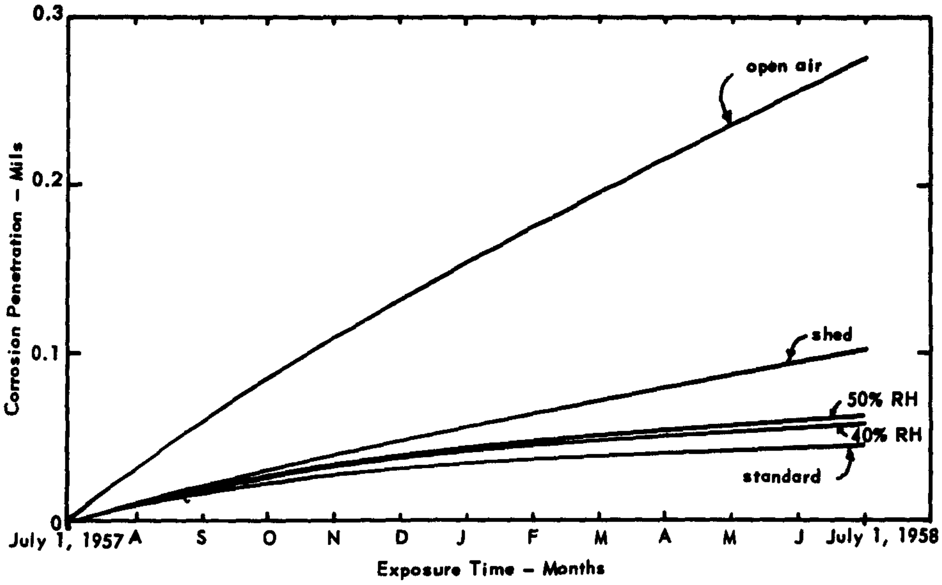


Figure 5. Curve set for corrosometer copper probes.

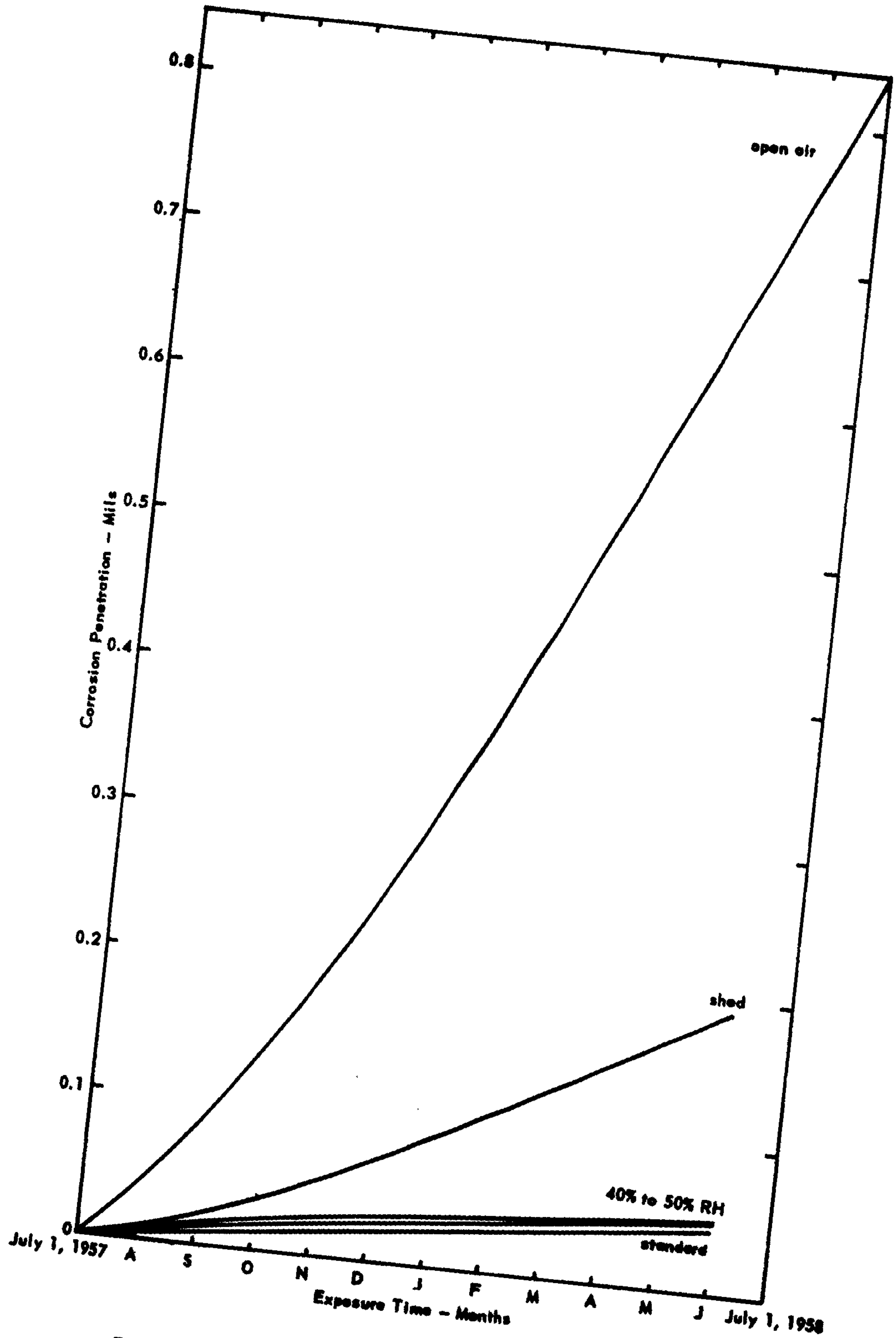


Figure 6. Curve set for corrosometer aluminum probes.

The set of curves of Figure 6 are for the aluminum probes. These curves show a significant rate of corrosion difference between the open air and the remaining environments. As was the case for the copper probes, the corrosion rate in the standard warehouse is below that in the dehumidified warehouses although the difference is again small. Note that the rate of corrosion for aluminum tends to accelerate with time, but that steel and copper corrosion tends to decelerate. A steel probe obtains valid corrosometer information faster than either the aluminum or the copper probes.

The corrosometer readings should not be considered entirely indicative of actual equipment rusting progress. The real value of the corrosometer lies in the fact that with this instrument, potential significant corrosion may be predicted for any storage environment provided air psychrometry data is known. If, for example, the corrosometer readings, the temperature, and partial pressures of the water vapor in any given environment are similar to those obtained in these tests, it would be reasonable to expect similar corrosion rates. Perhaps the corrosometer and air psychrometry data may be combined to produce an empirical equation which could predict the corrosion producting potential of atmospheres. This, however, must be left for future work.

b. Climatic and Psychrometric Data

The climate under which these tests are being conducted is mild the year around. The prevailing wind is from the west and is high in moisture content. The rainfall usually occurs during the winter and has averaged less than 13 inches a year for the duration of the tests to date. Psychrometric data for each storage environment are given over a 30-month span by the temperature, relative humidity, and vapor partial pressure curves in Figures 7 through 10. These curves are based on four-week averages.

The open-air and shed environments are considered to have the same air psychrometry, and they share the same curve, Figure 7. The yearly temperature, is nearly sinusoidal for these environments with an approximately 15 F amplitude. Mean lows vary from 50 to 55 F and the mean highs from 65 to 70 F. The relative humidity curve for the open air-shed shows a conspicuous drop during the late fall and early winter months. This drop is caused by frequent hot and dry east winds which lower relative humidity. These winds are a seasonal occurrence. During this period relative humidities as low as 5% have been occasionally recorded, but the average generally falls between 30 and 40% despite periodic rains. The relative humidity during the remainder of the year approximates 70%. The vapor partial pressure varies directly with the dry-bulb temperature and relative humidity. The vapor partial pressure curve is somewhat sinusoidal with an amplitude of about 0.3 inches of mercury and varies from 0.2 inches to 0.5 inches.

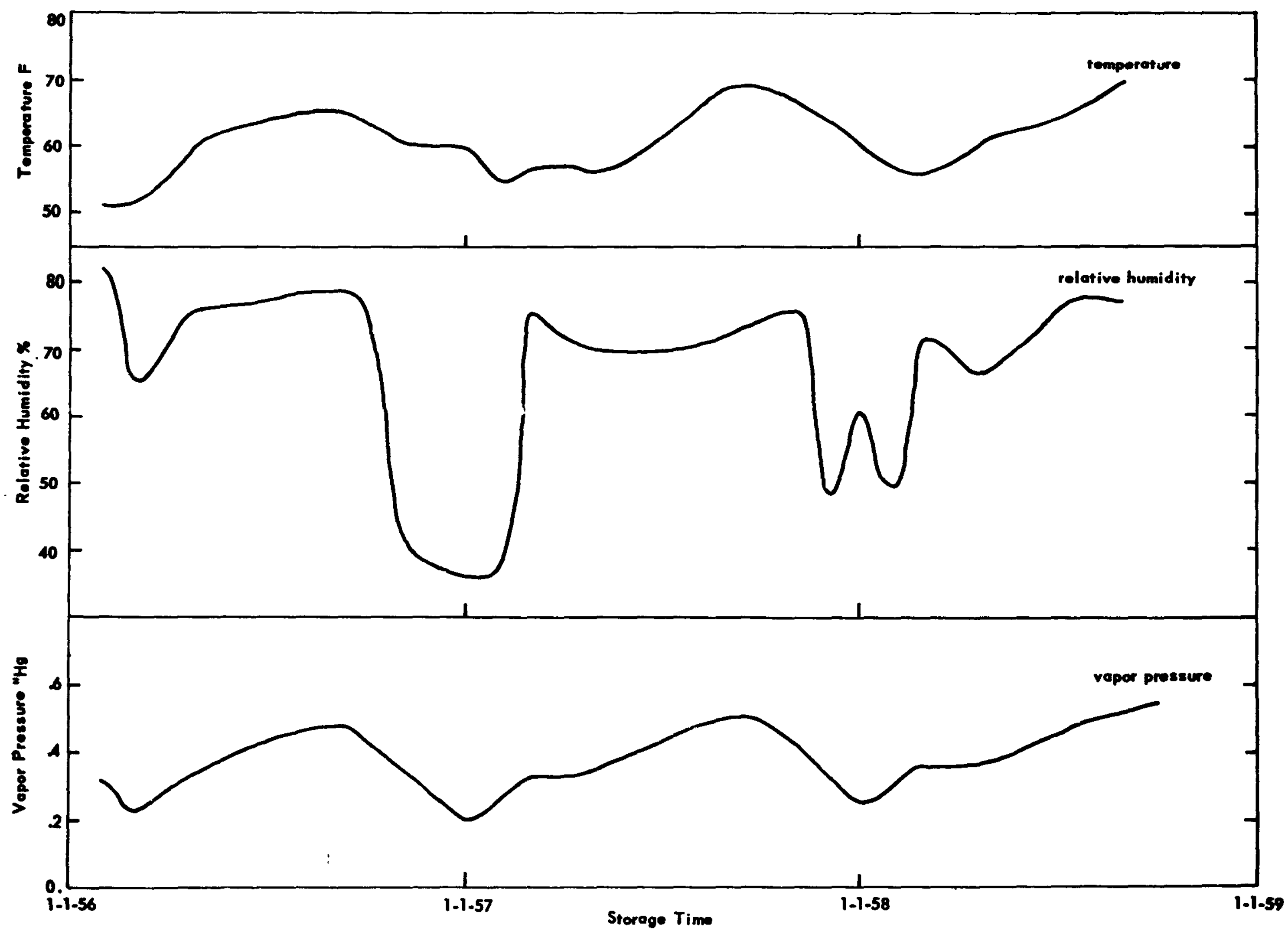


Figure 7. Average temperature, RH, and vapor pressure for open air slab and shed from 1 Feb 1956 to 1 Sept 1958.

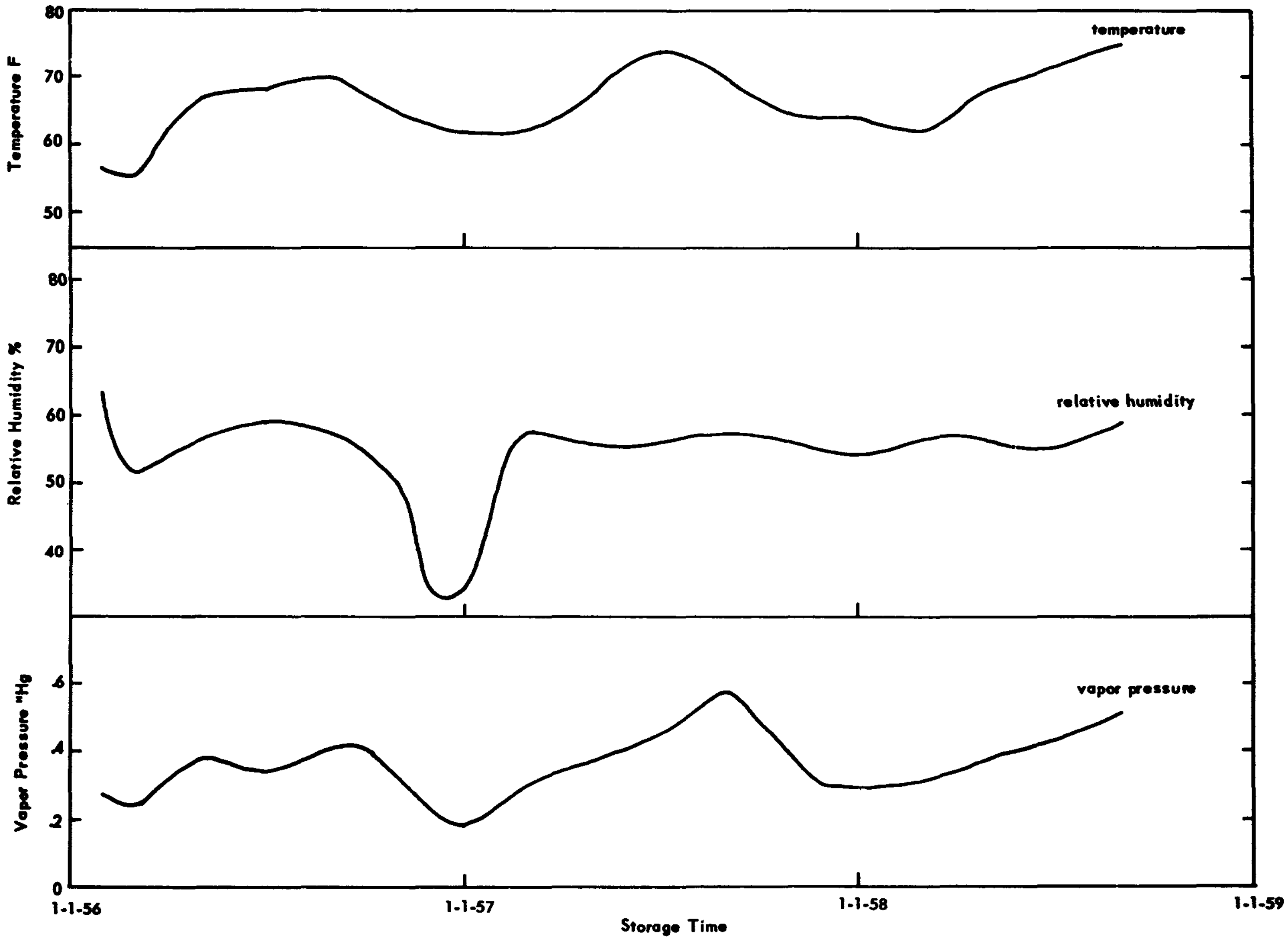


Figure 8. Average temperature, RH, and vapor pressure for standard warehouse from 1 Feb 1956 to 1 Sept 1958.

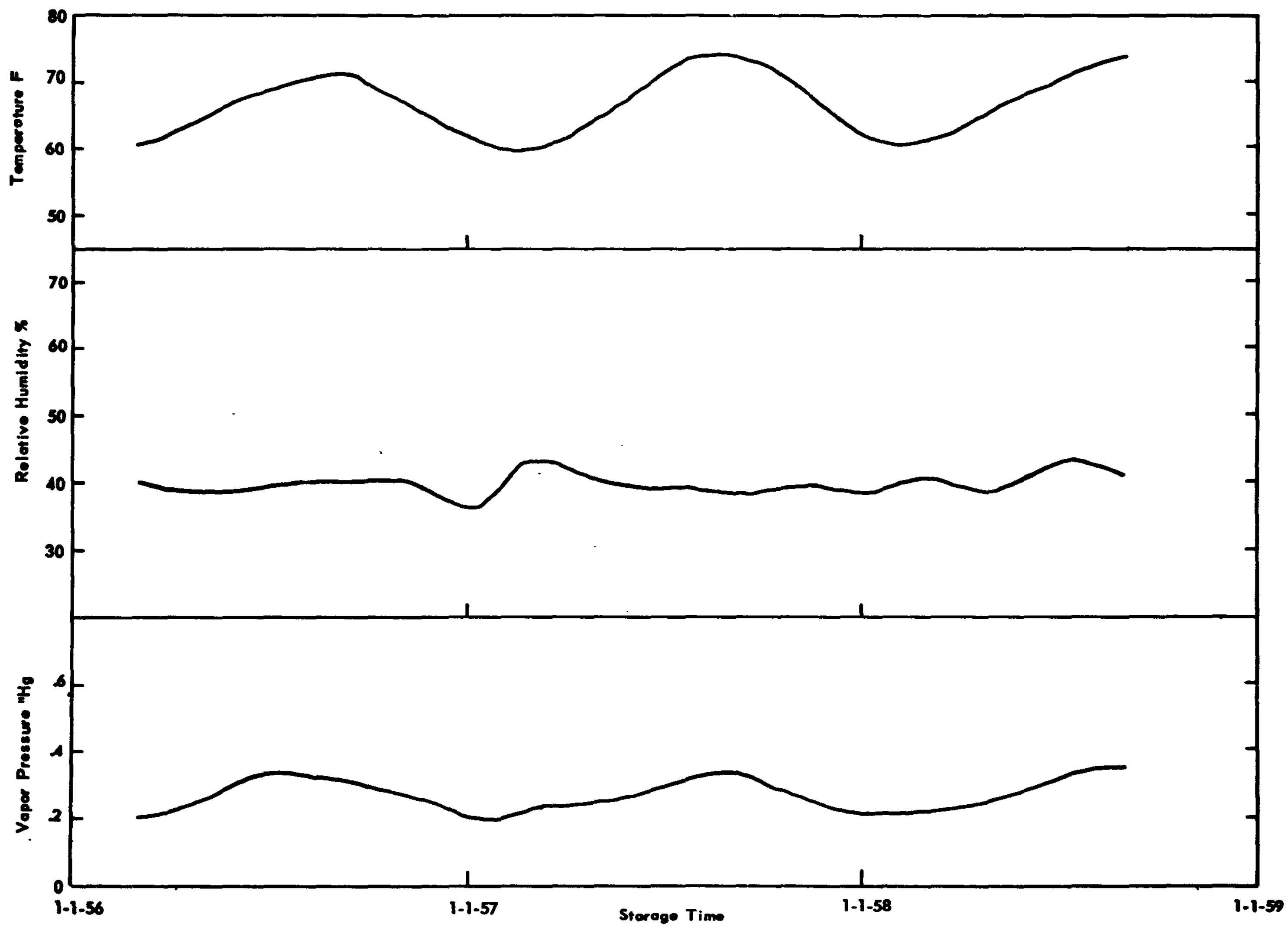


Figure 9. Average temperature, RH, and vapor pressure for 40% RH warehouse from 1 Mar 1956 to 1 Sept 1958.

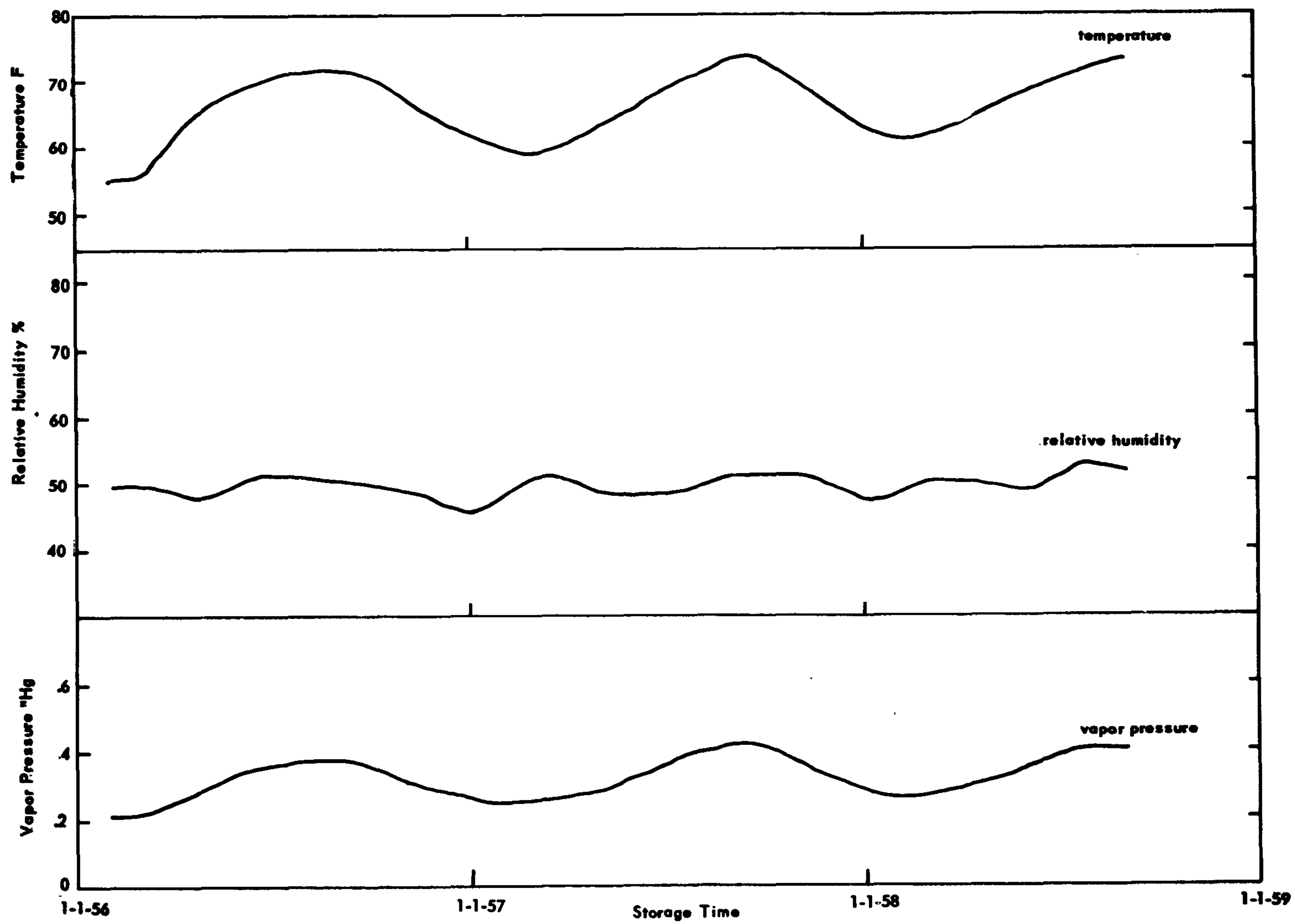


Figure 10. Average temperature, RH, and vapor pressure for 50% RH warehouse from 1 Feb 1956 to 1 Sept 1958.

The yearly curves of the standard warehouse, Figure 8, are similar to those of the open air-shed curves. The temperature variation again is nearly sinusoidal with an approximate 15 F amplitude, but it is about 5 F warmer inside the building. The mean lows vary from 55 to 62 F and the mean highs from 70 to 75 F. The building itself dampened the fluctuations of the relative humidity somewhat, and its variations are less pronounced during the winter months. During the period of hot dry east winds, the relative humidity drops to around 15% but throughout the fall and winter months the average fluctuates between 40 and 45%. The relative humidity during the remainder of the year is around 55%. The vapor partial pressure curve reflects less of a sinusoidal pattern than the open air-shed curve, and it varies from approximately 0.25 to 0.58 inches of mercury.

The yearly curves for the controlled humidity warehouses are shown in Figures 9 and 10. The temperature curves for both the 40% RH and 50% RH environments are sinusoidal with an approximate amplitude of 15 F. The desiccant machines add heat to the warehouse air when a newly reactivated bed is cycled into use. Therefore, it is slightly warmer in the dehumidified warehouses than in the standard warehouse. Also, because of longer desiccant machine operation, it is a little warmer in the 40% RH than in the 50% RH building. The relative humidity in each building was held to within ±3% RH of the designated level. The vapor partial pressure curves are sinusoidal and vary mostly with the temperature since the RH in each environment is essentially constant. The vapor partial pressure in the 40% RH warehouse varies from approximately 0.20 to 0.34 inches of mercury, and in the 50% RH warehouse from approximately 0.24 to 0.42 inches of mercury.

The overall arithmetical average of the temperature, relative humidity, and vapor partial pressure for each type of storage is given below in Table 2.

Table 2. Average Temperature, Relative Humidity, and Vapor Pressure From Start to September 1958

Environment	Temperature °F	Relative Humidity %	Vapor Pressure in. Hg
Open Slab & Shed	61.1	68.9	.378
Standard Warehouse	66.0	55.0	.363
50% RH Warehouse	66.5	49.0	.327
40% RH Warehouse	67.3	39.7	.272

c. Rusting Index

Rusting which had occurred up to May 1957 was described in previous NCEL letter reports.[1] Rusting indices were not included in those reports because the system of rust classification presented on page 6 of this report had not been officially submitted for field use. An interim technical note report for BuDocks is in progress which will list all the rusted areas to date, area covered, class of rust, and will include some representative photographs.

Table 3 lists the rusting index of items stored in the open slab, shed, and standard warehouse at 30 months. The dehumidified warehouses are not listed since the items have not rusted while stored in them. The rusting index was obtained by applying the weighted numbers for degree and amount of rust coverage which are shown in the chart on page 7 to the 30 month's inspection results. Results of the open slab test are complete and include the findings of class III inspection. The figures for the Open Air items are extrapolated from all class II inspections through 27 months, since the 30 month inspection on these items was a class III inspection. The figures for the shed and standard warehouse are probably low since they are compiled from only class II inspections.

The rusting index figures which describe the domestic-treated, open-stored vertical boiler, bake oven, centrifugal pump, and arc welder are for 12 months storage, and the figure for the generator set are for 24 months. The boiler, oven, pump, and generator had to be removed to prevent permanent, extensive rust damage. The arc welder was removed from storage and shipped to meet an urgent operational need.

As was expected, the highest rusting index figures are for domestic-treated, open-air items; these have the least protection. Conversely, inspections so far show that items with the lowest rusting index are the contact-preserved items in the most protected environments.

d. Rust Count Curves

An indication of comparative storage efficacy can be obtained from the rust count curves in Figures 11 and 12 which were plotted from class II inspection data. The last class II inspection of the open-air slab was made at 27 months; the final class III inspection was made at 30 months. The dotted portion of the curves from 27 to 30 months is an extrapolation. This extrapolation indicates that the class II inspection misses about 21% of the rusted areas of domestic-treated items and 5% of the contact-preserved items.

Table 3. Rusting Index at 30 Months

	Open Air Class III Insp		Open Air Class II Insp		Shed Class II Insp		Standard Class II Insp	
	Dom.	Cont.	Dom.	Cont.	Dom.	Cont.	Dom.	Cont.
Boiler, Vertical	14.7[1]	0	7.6	0	8.0	0	0.2	0
Compressor Set, Air	9.7	3.8	9.7	3.8	8.0	3.5	3.0	4.0
Distillation Unit	9.0	4.2	5.0	0.2	0.5	0.2	4.0	0
Generator Set	6.8[2]	5.0	6.8	5.0	2.2	0.5	2.2	0.6
Heater, Oil Fired	16.0	1.5	16.0	1.5	14.5	0	8.0	0
Machine, Washing	13.8	0.3	13.2	0.3	0	0.8	0	0
Oven, Bake	10.0[1]	0	10.0	0	8.0	0	3.7	0
Pump, Centrifugal	10.0[1]	0	3.0	0	2.5	0	0	0
Pump, Diaphragm	8.7	1.5	8.7	1.5	4.5	4.0	0	0
Refrigeration Unit	10.0	1.5	8.0	1.5	4.7	1.2	0	0
Refrigeration Panels	8.0	2.0	8.0	2.0	2.0	0.5	0	0.5
Searchlight w/p.p.	20.3	3.3	13.5	3.3	1.8	1.7	1.0	1.0
Tank, Canvas	2.0	0	2.0	0	0	0	0	0
Tires	--	--	--	--	--	--	--	--
Trailer, Floodlight	16.6	5.4	9.8	5.0	3.0	2.6	1.3	0.8
Transfer Unit, CO_2	0.3	0	0.3	0	0	0	0	0
Truck, Dump	13.5	6.5	8.0	.75	2.5	2.5	0.5	0.3
Truck, Jeep	22.8	2.0	18.8	2.0	15.8	0.3	0.8	0
Welder, Arc	2.5[3]	2.0	2.0	2.0	10.0	0	4.8	0

1. Item removed from storage after 12 months to prevent permanent damage.
2. Item removed from storage after 24 months to prevent permanent damage.
3. Item removed from storage after 12 months for shipment.

Note: All D/H warehouse stored items showed index of zero.

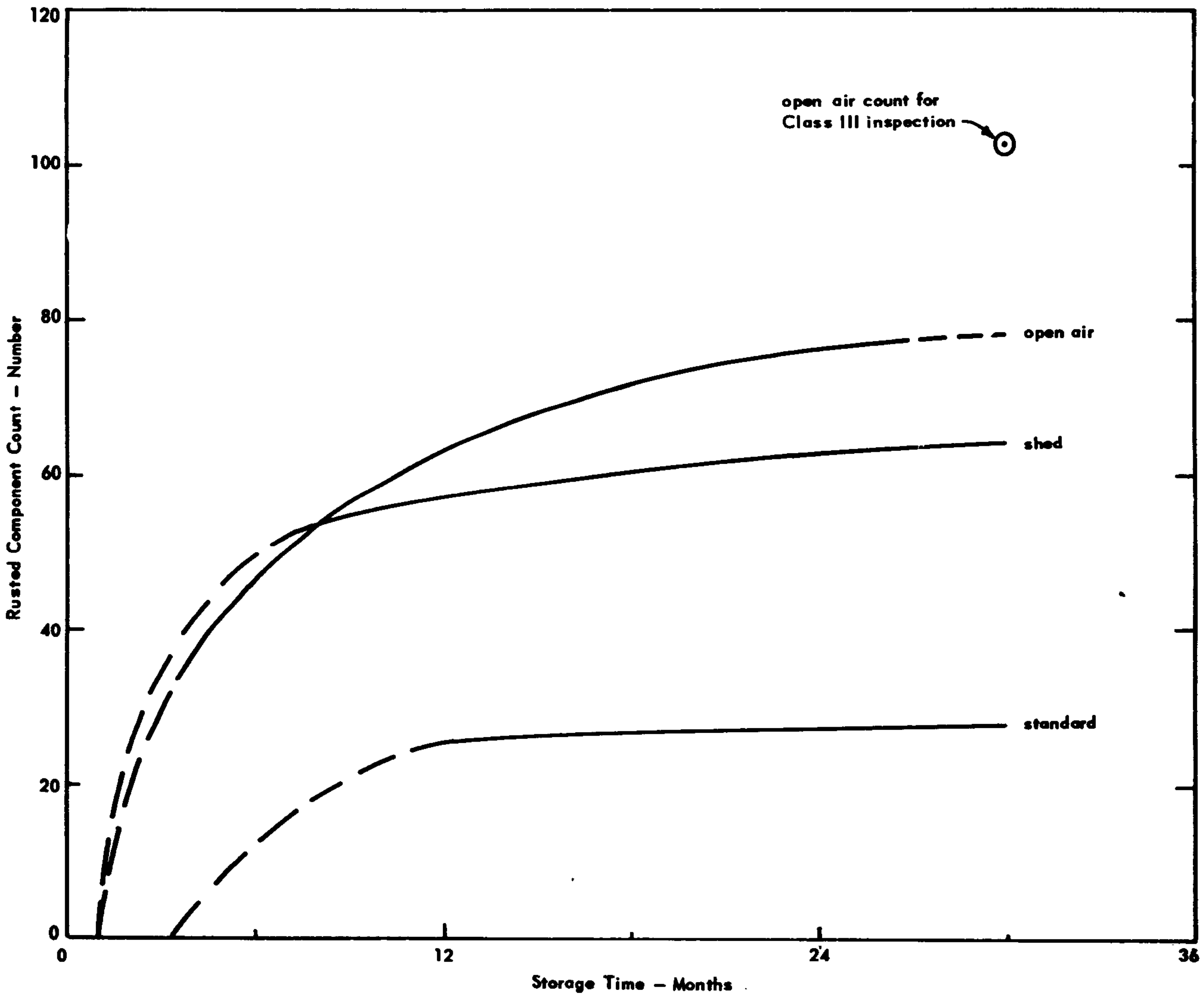


Figure 11. Rust count curves for domestic treated items.

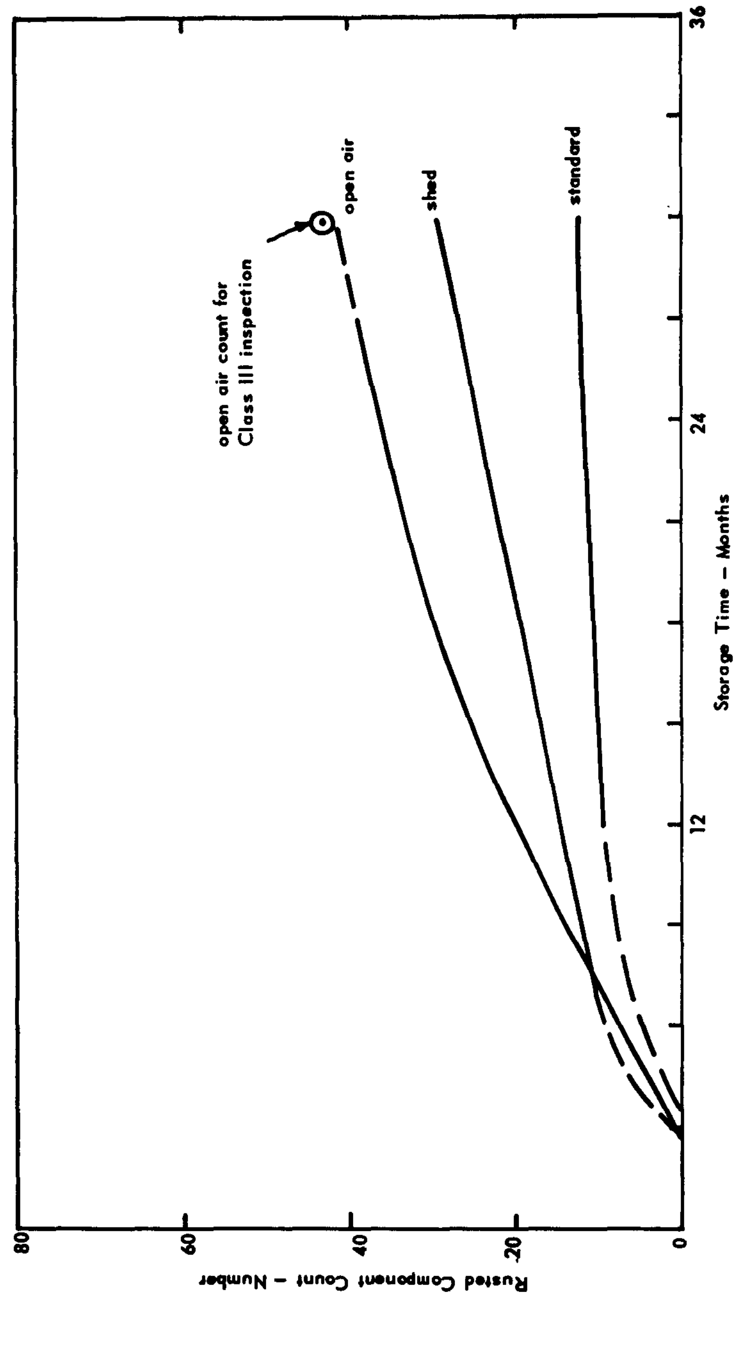


Figure 12. Rust count curves for contact preserved items.

The open air-slab curves, because of the class III inspection, offer the best evaluation of contact-preservation. There were 103 rusted areas for domestic-treated items while only 43 were counted for contact-preserved items. This is a 58% reduction. Definite comparisons between domestic-treated and contact-preserved items in each environment can only be made after the class III inspection at the end of the 5-year test period. Based on class II inspections, in the shed and standard warehouse, however, there are approximately 50% fewer rusted, contact-preserved areas than domestic-treated ones.

The beginning dotted portion of each curve is an extrapolation to zero deterioration. From this, it appears that rust will begin forming in about 4 weeks on domestic-treated items stored outside or in a shed, and about 6 weeks in a standard warehouse. Contact-preserved items stored in these 3 environments should begin rusting in about 3 months.

No curves have been prepared for the two dehumidified warehouses because no rusting occurred in these environments. Some items rusted while stored in a shed for 4 or more weeks waiting for the dehumidified buildings to be erected; subsequent storage in the dehumidified warehouses arrested this rusting, and no new areas have developed.

e. Rehabilitation Costs

Table 4 lists the rehabilitation costs that were estimated after 30 months from the records of a class III inspection of open-air-stored items. Rehabilitation costs for items in the other environments will be available after a class III inspection at the end of the 5-year period. Comparison of the domestic versus contact items on table 4 reveals that rehabilitation costs may be substantially lowered by contact-preserving items stored in the open air.

f. Preservation Materials

The test has shown that the ability of the various types and varieties of preservative materials to endure a given storage period and maintain equipment in a rust-free condition generally closely follows the ability of the storage environment to provide protection. That is, the less protection an environment offers, the quicker the preservative materials will weaken. For example, the preservative materials on equipment stored in the open air either cracked, pealed, drained, or otherwise weakened to the extent that representation was necessary after 30 months of storage. In higher levels of storage, preservative deterioration was not nearly as severe for the 30-month storage period; in fact, in the dehumidified units, the preservatives appear to still be in excellent condition although there was some drainage of the preservatives from vertical surfaces.

Table 4. 30-Month Rehabilitation Cost For Open-Air-Stored Items Based Upon Class III Inspection

Item Stored	Rehabilitation Cost Dom.	Rehabilitation Cost Cont.
Boiler, Vertical	$ 41.60[1]	$ 0
Compressor Set, Air	32.20	28.60
Distillation Unit	35.10	26.00
Generator Set	168.40[2]	62.40
Heater, Oil Fired	14.30	6.50
Machine, Washing	15.60	3.90
Oven, Bake	22.10[1]	0
Pump, Centrifugal	84.50[1]	0
Pump, Diaphragm	8.80	2.60
Refrigeration Unit	23.40	6.50
Refrigeration Panels	41.10	10.40
Searchlight w/p.p.	137.80	26.00
Tank, Canvas	0	0
Tires	--	--
Trailer, Floodlight	$ 69.70	$65.30
Transfer Unit, CO_2	5.20	0
Truck, Dump	185.40	63.70
Truck, Jeep	64.20	3.90
Welder, Arc	46.80[3]	31.20

1. Item removed from storage after 12 months to prevent permanent damage.

2. Item removed from storage after 24 months to prevent permanent damage. Cost was mainly for new fuel injectors.

3. Item removed from storage after 12 months for shipment.

g. Related Tasks

There are other tasks that are similar or related to this task. One task, Y-R007-08-406, "Non-Specification Preservatives," is concerned with the effects of open-air storage on certain non-specification preservatives. Its object is to determine the preservation methods and types of materials which are most effective for outside-stored vehicles and equipment without cyclic preservation and with a minimum depreservation at reactivation time. Another task, Y-R007-08-906, "Teflon Treated Jeep," is evaluating the ability of a teflon film to protect the internal working surfaces of a military jeep. A third task, Y-F015-04-005, "Investigation of Desiccant Dusting," is studying the problem of desiccant dusting during dehumidification machine operation to eliminate or minimize this condition. The concern here is that small bits of moisture-laden desiccant may be blown into the air from the machine and settle on stored equipment. Desiccant dusting may no longer be a problem, however, for the tendency of the desiccant to break up into fine particles has been largely overcome by use of new, sturdier desiccants that are now commercially available.

h. The Navy Standard Building For Advanced Base Dehumidified Warehouses

The Navy standard prefabricated 40-ft x 100-ft metal building appears so far to be a suitable building for advanced base dehumidified storage. It would be necessary, however, to eliminate the louvers and windows and tighten the cargo door fit if the building is adopted. Depending upon circumstances, it might also be desirable to eliminate the cargo door at one end to preclude the chance of through ventilation. In locales of high partial vapor pressures, the building needs insulation to dampen daily temperature variations and to reduce the possibility of water vapor condensation on equipment. But in locales of low partial vapor pressure areas (arid and cold regions), insulation is not needed to prevent condensation because the dew point would rarely drop to condensing temperatures.

Sealing the building may or may not be required. The cost of sealing the test buildings was about \$600 each and the annual machine power cost in the 50% RH building was \$52 (4 cents per kwh). If the machine operated four times longer in a loose building than in the sealed test building, the annual power cost would then be \$208. This divided into the \$600 sealing cost equals approximately 3 years. Thus, sealing becomes economically feasible only if the building is to be used longer than 3 years. The annual measured power cost of the desiccant machine in the 40% RH building was \$101. The economical break-even point at the RH level would be about 1-1/2 years assuming a building with the same degree of looseness. Actually, the economical break-even point will vary with the factors of building tightness, geographical location, power and labor costs. Whether or not a building needs sealing should be determined on an individual basis, by minimizing, with time as the independent variable, the sum cost of sealing and desiccant machine operation. For its D/H test buildings, NCEL used a bituminous, cut-back cement sealing material. After 2-1/2 years the 50% RH building leaked air slightly. Table 5 tabulates three pressurization tests for building tightness. In each test the D/H buildings were pressurized by introducing a known rate of outside air. The 40% RH building needed a higher rate because the sealing job was probably not as thorough as that of the 50% RH building. However, that the sealing in the 40% RH building was not measurably loosened is manifested by the constant resultant building pressure of .22 ± .01 in. of water while the sealing in the 50% RH building has loosened some as indicated by the nominal decrease in building pressure from 0.16 to 0.10 in. of H_2O. This loosening, however, did not noticeably increase D/H machine operation, and for this reason the loosening is not of major consequence.

Table 5. Pressurization Tests

Date	Building	Building Manometer
Feb 1956	50% RH	0.16 in. H_2O
	40% RH	0.22
Jan 1957	50% RH	0.11
	40% RH	0.23
Oct 1957	50% RH	0.10
	40% RH	0.21

The desiccant machine operation and power consumption is given in Table 6. The machine in the 40% RH warehouse operates 2 times as much as the machine in the 50% RH warehouse. The 40% machine uses 2/3 more power per lb of water removed to obtain the 10% RH reduction. This is due to the fact that a desiccant machine operates less efficiently in a dryer atmosphere.

Table 6. Desiccant Machine Operation And Power Consumption*

Warehouse RH level	Operating hours per year	Kwh per year	Kwh per lb of water removed
50%	495	1275	1.30
40%	1014	2528	2.18

*Based on a 2-yr average from Oct 4, 1956 to Oct 2, 1958.

Table 6 is based on data obtained after the initial RH drawdown was complete and the machines were cycling on and off fairly regularly.

PART B - ECONOMY OF STORAGE

a. Introduction

The preceding sections described various storage environments and compared their ability to protect materiel from rust. Indications of their efficiency were shown by Corrosometer readings, rusting indices, rust count curves, and rehabilitation costs. These data, while informative and useful, reveal only a part of the total storage picture. The part that is missing is storage economy, the dollars and cents of storage.

High commodity and services prices make it necessary that each DOD branch operate as efficiently, effectively and inexpensively as possible commensurate with national security. The introduction of this report indicates that war materiel stand-by storage costs the taxpayer about 3/4 billion dollars each year. This cost might be reduced.

Complete storage costs for any particular environment is the sum of many individual costs; rehabilitation cost, building cost, maintenance cost, preservative material and application cost, equipment inspection cost, and others. Total complete cost also varies with combinations of storage environments, preservation levels, and time. These factors control storage costs. For example, there is no construction cost if equipment is stored on the ground outdoors, and conversely, a sizeable construction cost if equipment is stored within a controlled humidity warehouse. Yet equipment stored outdoors must be thoroughly preserved and frequently inspected, whereas equipment stored indoors requires less preservation and less frequent inspections. Influencing each, however, is time. An item to be stored for only a few days may be kept outdoors with a minimum of preservation, but if it is to be stored for a few years, other storage environments and preservation levels are required. This problem can be resolved by determining which combination of storage environment and preservation levels, commensurate with time, costs least.

The NCEL test was a good opportunity to study storage costs. Nearly all the factors necessary for a cost analysis were present or could be obtained from CBC warehousemen and preservative specialists.

While costs based on the NCEL tests might not necessarily reflect actual conditions, they could be sufficiently illustrative to provide a guide for predicting actual field storage costs. Thus, the study was considered justified. A lot size of 25 units of each item in the test was chosen, for this size was most representative of CBC stores at the time the data were being accumulated. Any lot size, however, could have been used. For the purpose of uniformity, the procedures specified in the "Quality Control Procedures for Surveillance and Inspection," NavDocks TP-QC-1, were applied to all stored materiel.

b. Equation For Storage Costs

All the individual costs attributed to storage are formulated into a cost equation in which the sum of these individual costs are equated to the total cost. By comparing results, it is possible to determine the most economical storage method for any particular item. For expediency, the formula was programmed on the IBM 705 data processing computer at CBC, and all storage cost calculations were done by this computer. The formula, which is linear and contains 18 cost factors, is as follows:

$$W = A_{ij}L + B_{ij} + C_iD_iT + L\left[(U_{ij}KF_{ij}) + (V_{ij}YG_{ij}) + H_{ijt} + M_{ijt}\right] + TC_iE_i + N_{ijt} + S_{ij}P_{jt}$$

A brief explanation of each factor in alphabetical order is as follows, and a thorough explanation and the source of machine data is in Appendix B. In all cases, it is assumed that the equipment to be stored is new and not yet deteriorated.

A = The labor hours to initially prepare for storage

B = Material cost to initially prepare for storage

C = Square footage required for storage

D = Unit cost of storage per square foot per month

E = Storage maintenance cost per square foot per month

F = Labor hours for item inspection

G = Labor hours for operational testing only

H = Labor hours for depreservation

i = Subscript that denotes "With respect to type of storage environment."

j = Subscript that denotes "With respect to particular item stored."

K = Ratio of sample size to lot size

L = Hourly labor charge

M = Rehabilitation cost

N = Material cost for crating, dunnage, boxing, etc.

P = Original cost of item less depreciation

S = One (1) if item is found to be unrepairable, zero (0) otherwise.

t = Subscript that denotes "With respect to time."

T = Storage time in months

U = Number of class II inspections

V = Number of operational tests

W = Total costs

Y = Ratio of operationally tested items for lot size

c. Results

All the costs which follow are based on a storage period of 30 months. The equipment has been segregated into categories of similar design or function, and storage cost-time curves are drawn for each category. There are six equipment groups.

Group I. Fluid Handling Equipment

1. Centrifugal pump, 350 gpm
2. Compressor set, 30 cfm
3. Diaphragm pump, 50 gpm
4. Distillation unit, 83 gph
5. Refrigeration unit
6. Transfer unit for CO_2
7. Washing machine

Group II. Motor-Generator Equipment

1. Arc welder, 300 amp
2. Floodlight trailer
3. Generator set, diesel, 30 kw
4. Searchlight unit with power plant

Group III. Automotive Equipment

1. Dump truck, 2-1/2 ton
2. Jeep, 1/4 ton

Group IV. Heating Equipment

1. Bake oven
2. Oil-fired space heater, 50,000 Btu
3. Vertical boiler, 180,000 Btu

Group V. Non-metallic Equipment

1. Canvas tank
2. Refrigeration panels

Group VI. Tools, Instruments and Communications Equipment

1. Drill press, 18 inch
2. Exhaust fan, 4900 cfm
3. Lathe, floor model
4. Meat slicer
5. Public address system
6. Radial saw, 16 inch
7. Surveyor's transit
8. Switch board, 50 line
9. Telephone system, 13 unit

The equipment of group VI appears to be somewhat miscellaneous but has been classed together because the items are stored in either a standard or dehumidified warehouse - never outside or in a shed. The equipment in the other groups, on the other hand, are stored in various environments. Tires (8.25 x 30) are missing from group V and chemical warfare detector kits from group VI because rusting does not usually affect them. It would be difficult to correctly assess their deterioration until other methods are devised. Unmounted tires were, however, tested in all storage conditions and appeared to be in excellent condition. No comparative in-service test with new tires has been made. The chemical warfare kits consisted of vials of certain liquid chemicals. The chemicals appeared to be in excellent condition, but have not been analyzed further.

The curves showing storage costs of the various groups of categories of equipment are given in Appendix C. The cost-time curves of individual items follow their parent group curves as figure-letter subscripts. The group curves graphically show cost-time relationship of the total of the sums of each item within the group. The individual cost-time curves are a summation of preservation and storage costs including the depreservation cost of contact-preserved items. It is stressed that the curves represent storage period costs only and do not include subsequent post-storage costs such as preserving domestic-treated equipment for overseas shipment. This subsequent charge, and others, are presented later in this section.

Factors affecting storage costs that are common to each environment have been disregarded in this storage cost analysis. Deterioration of rubber goods is one such factor. As an example, the sidewalls and treads of mounted tires all cracked and checked about equally irrespective of the storage environment. The CBC policy is to re-tire on activation any equipment which has been stored for more than 5 years. Deterioration of stored batteries is another common factor, but this has been largely eliminated by specifying the dry-charge type. These batteries have a long shelf life, and if kept in the dry state during storage, may last 10 or more years. The dollar-depreciation of the stored materiel has also been disregarded, for it was felt that each like item was affected equally regardless of its storage environment. Depreciation due to obsolescence becomes a storage cost factor in areas of fast moving technology such as ordnance, electronics, and aircraft. Technological advances or radical design changes in construction and other allied equipment required by the Naval Shore Installations may occasionally render some BuDocks stores obsolete; but such instances are so few that obsolescence was not included in this study.

The curves of Group I, Figure C1, show that storing domestic-treated equipment in a 50% RH dehumidified warehouse is least expensive. The costliest method is contact-preserved equipment stored outdoors. Table 7 and succeeding tables show an ascending order of storage costs at each preservative treatment for each storage environment.

Table. 7 30-Month Storage Cost for Group I Equipment

Environment	Treatment	Cost - Dollars
50% RH warehouse	Domestic	297
40% RH warehouse	Domestic	300
Standard warehouse	Domestic	353
Shed	Domestic	477
50% RH warehouse	Contact	675
40% RH warehouse	Contact	677
Standard warehouse	Contact	715
Shed	Contact	758
Open air	Domestic	759
Open air	Contact	873

Group II curves, Figure C2, show that the least expensive storage for a period of 30 months is domestic-treated equipment in a 50% RH warehouse while the most expensive is contact-preserved equipment stored in the open air. Table 8 shows the storage costs for this group.

Table 8. 30-Month Storage Cost for Group II Equipment

Environment	Treatment	Cost - Dollars
50% RH warehouse	Domestic	221
40% RH warehouse	Domestic	225
Standard warehouse	Domestic	365
50% RH warehouse	Contact	576
40% RH warehouse	Contact	579
Shed	Domestic	607
Standard warehouse	Contact	644
Shed	Contact	714
Open air	Domestic	906
Open air	Contact	1042

Group III curves in Figure C3 show domestic-treatment in a standard warehouse to be the most economical and contact-preservation in the open-air warehouse to be the least economical storage method. Table 9 shows the storage costs for the group.

Table 9. 30-Month Storage Cost for Group III Equipment

Environment	Treatment	Cost - Dollars
Standard warehouse	Domestic	468
50% RH warehouse	Domestic	521
40% RH warehouse	Domestic	538
Shed	Domestic	594
Open air	Domestic	700
Standard warehouse	Contact	711
50% RH warehouse	Contact	750
40% RH warehouse	Contact	767
Shed	Contact	810
Open air	Contact	828

Group IV curves in Figure C4 show domestic-treatment and storage in either the Standard, 40% RH, or 50% RH dehumidified warehouses as the most economical, while contact-preservation in open air as least economical. Table 10 lists the storage costs for this group.

Table 10. 30-Month Storage Cost for Group IV Equipment

Environment	Treatment	Cost - Dollars
Standard, 40% & 50% RH warehouse	Domestic	102
Shed	Domestic	179
Standard, 40% & 50% RH warehouse	Contact	184
Shed	Contact	193
Open air	Domestic	213
Open air	Contact	225

Group V curves in Figure C5 show that domestic-treatment and storage in the standard warehouse is most economical while contact-preservation in the 40% RH or 50% RH dehumidified warehouse is least economical. Table 11 lists the storage costs for this group.

Table 11. 30-Month Storage Cost for Group V Equipment

Environment	Treatment	Cost - Dollars
Standard warehouse	Domestic	86
40% & 50% RH warehouse	Domestic	91
Shed	Domestic	94
Open air	Domestic	116
Open air	Contact	156
Shed	Contact	158
Standard warehouse	Contact	161
40% & 50% RH warehouse	Contact	165

Group VI curves in Figure C6 show that domestic-treatment in standard warehouse storage is the most economical and contact-preservation in this same environment is least economical. This equipment is stored only in standard or dehumidified warehouses. Storage costs for this group are listed in Table 12.

Table 12. 30-Month Storage Cost for Group VI Equipment

Environment	Treatment	Cost - Dollars
Standard warehouse	Domestic	242
50% RH warehouse	Domestic	249
40% RH warehouse	Domestic	250
50% RH warehouse	Contact	505
40% RH warehouse	Contact	507
Standard warehouse	Contact	511

d. Sensitivity Tests

Sensitivity checks of the data were made to determine the effect of each individual cost on the total storage cost. It is quite important to know this because information presented here would not be very useful if it could not be safely extrapolated to conditions other than those of the test. The checks were made by increasing or decreasing certain cost data of the IBM program and a run made on a 30-month storage period. The run was made on Group I items and the results of this run are given in Table 13. In all cases the total storage cost varied in direct proportion to the independently varied parameter giving assurance of safe extrapolation. The left hand column of Table 13 describes the variable and columns to the right give resultant costs and difference from base cost. The top horizontal line gives the base costs from which the resultant costs vary.

Table 13. Storage Cost Deviation For Group I Items Under Varying Circumstances For 30 Months Of Storage

Circumstance	Open Air		Shed		Standard		50% RH		40% RH	
	D+	C+	D	C	D	C	D	C	D	C
None - base cost	$759	$873	$477	$758	$353	$715	$297	$675	$300	$677
Decrease labor from $2.60 to $2.00 per hr.	627	737	421	657	328	626	288	601	291	603
Under base cost	132	136	56	101	25	89	9	74	9	74
Increase labor from $2.60 to $3.20 per hr.	891	1008	533	859	379	800	303	750	306	752
Over base cost	132	135	56	101	26	85	6	75	6	75
Decreasing lot size from 25 to 8 units	1349	1170	760	880	471	765	348	726	351	728
Over base cost	590	297	283	122	118	50	51	51	51	51
Increasing lot size from 25 to 40 units	611	797	404	725	326	700	283	611	286	663
Under base cost	148	76	73	33	27	15	14	14	14	14
Double warehouse cost (D & E of formula)	786	900	532	824	429	791	396	774	403	780
Over base cost	27	27	66	66	76	76	99	99	103	103
Increase rehabilitation cost by 27% (M of form.)	808	890	493	770	365	723	NC*	NC	NC	NC
Over base cost	49	17	16	12	12	8	-	-	-	-
Double desiccant Mach. operation time	NA**	NA	NA	NA	NA	NA	330	708	350	727
Over base cost	-	-	-	-	-	-	33	33	50	50

+ D = Domestic treatment; C = Contact preservation

* No change

** Not applicable

Table 13 reveals that the condition having the most pronounced affect on base cost is decreasing the lot size of open-air storage. The total cost to store Group I items for 30 months jumped from $759 to $1349 for domestic treatment and from $873 to $1170 for contact preservation when decreasing lot size from 25 to 8 units. This variation is caused by the fact that inspection costs are prorated over fewer units. Inversely, the base cost decreased when the lot size was increased from 25 to 40 units with the domestic dropping $148 from $759 to $611 and the contact dropping $76 from $873 to $797. It will be noted that the increase is approximately 4 times the decrease. Lot size variation similarly affects shed storage, but the deviation from base cost is much less pronounced. The cost deviation continues to decrease with the standard warehouse and finally levels out with the D/H storage. Labor costs have a significant affect on cost, particularly the open air and shed environments. This is due chiefly to the number of periodic inspections required. These costs gradually taper down to D/H storage. Doubling warehousing costs has its greatest affect on the D/H structures. Base costs increased by $99 for the 50% RH building and $103 for the 40% RH building, and taper down to $27 for the open-air slab.

Increasing rehabilitation costs by 25% did not increase the base cost any great extent. Mostly affected was the domestic treatment - open air storage where cost was increased a nominal $49. Items within the D/H building remained rust-free during the 30-month storage period and, therefore, the base cost was unaffected.

Excluding doubling desiccant machine operation, in all circumstances except doubling warehouse cost, total storage cost of Group I items is least affected when domestic-treated equipment is stored in D/H warehouses and when contact-preserved equipment is stored either in the standard warehouse or D/H warehouses. As expected, doubling warehouse cost least affects total storage cost when either domestic-treated or contact-preserved equipment is stored in the open-air slab.

Based on a hypothetical environment, doubling desiccant machine operation was used to simulate machine operation in an unsealed building, not for a validity check. This information is useful in determining the extent of sealing necessary to convert existing unsealed warehouses to dehumidified ones. Doubling the machine operation gave an increase of $33 for the 50% RH building and $50 for the 40% RH building. These increases are not major and indicate that extensive sealing probably is not necessary and may, under certain circumstances, be omitted. Omission of sealing is discussed later. Although the base cost of Table 13 is founded on dead storage conditions, the power cost information obtained by doubling desiccant machine operation may also be applied to active dehumidified storage.

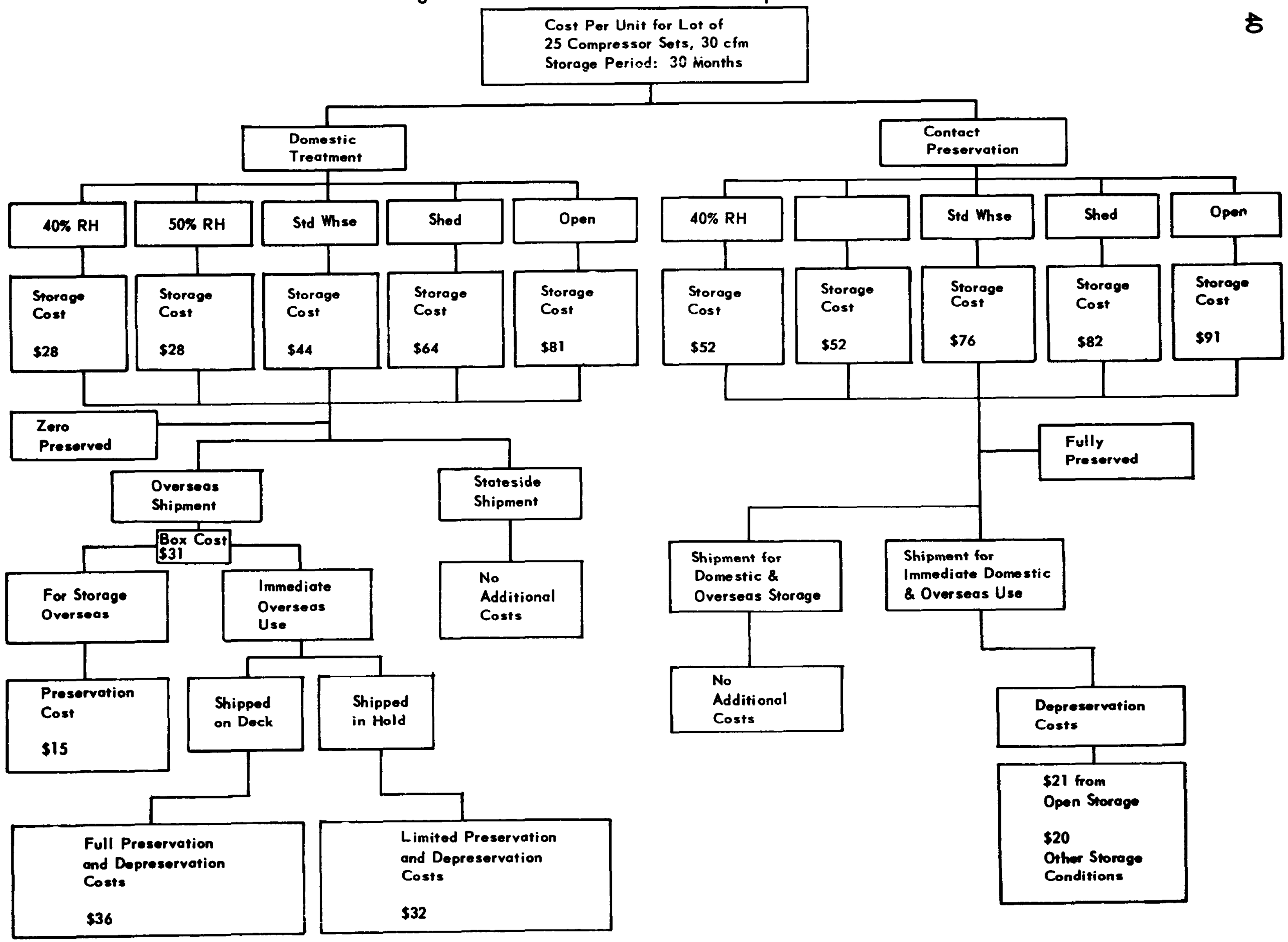
e. Cost Flow Charts

The results presented in section c give storage cost regardless of eventual equipment use. To prevent using these costs indiscriminately, cost flow charts have been prepared to illustrate that certain post-storage costs may be incurred that could completely change the overall results.

At the CBC, Port Hueneme, all materiel is mobilization reserve, and it must be ready for overseas shipment during the initial phase of Naval emergency. Except for some types of automotive and construction equipment that can be prepared for overseas shipments in a short time, all mobilization reserves are given contact preservation before they are stored. Organizations holding mobilization reserves for overseas shipment should not consider domestic treatment unless it meets overseas requirements or else may be easily modified in a short time with available manpower to do so. As a matter of information, however, the flow charts and explanation are for both domestic treated and contact preserved items for stateside and overseas use. As an example of how post-storage costs influence the entire storage situation, if a domestic-treated item is shipped to a stateside user, disregarding transportation costs, no additional cost of preservation or packing is incurred. If, however, this item is shipped overseas, it must be contact preserved against the corrosive sea air and placed in a box (if originally in an open crate). Box and crate costs for the various test items are given in Appendix F. The extent of preservation depends on whether the item is placed on the deck or in the hold of a ship. A final cost is then encountered to depreserve the item if it is to be put to immediate use. The preservative materials must be removed from contact-preserved items shipped stateside or overseas for immediate use, and this becomes a chargeable storage cost. If, however, the item is shipped stateside or overseas for storage, no additional costs are involved.

A sample chart is shown in Figure 13 while a complete set is given in Appendix D. The costs shown in the "storage cost" blocks for domestic treatment are the same as those for the 30-month storage period of the curves of Appendix C. The blocks for contact preservation show costs that are less because depreservation costs were deducted at this point and added later when destination was known. For the purpose of illustrating the use of the charts, it will be assumed that 50% of the equipment now in storage is destined for overseas and 50% for stateside use. The chart is for the 30-cfm compressor set and shows that the 30-month storage cost for domestic-treated items in either of the D/H warehouses is $28. This is the total cost if the items are not shipped overseas. If they are shipped overseas, an additional cost of $67 is incurred. This cost includes $31 to overseas box and $36 to preserve prior to deck shipment and depreserve at destination. The total cost then becomes $95 ($28 + $67). For the contact-preservation, the storage cost is $52 in either D/H storage and the depreservation cost is $20. The total is $72 regardless of destination.

Figure 13. Flow chart for 30 cfm compressor set.



The total cost of a domestic-treated compressor set stored outside for 30 months is $81 if not shipped overseas and $148 if deck shipped overseas. For contact preservation, the cost is $112 regardless of destination.

The Appendix D charts can be quite helpful in cost control if it is known in advance of storage the equipment's destination. If this is known then the best combination of preservation and available storage can be chosen to obtain lowest overall cost.

As an example analysis of how lowest cost can be determined, assume a hypothetical 50-50 split of overseas and stateside destinations of the compressor sets mentioned above. Assume also that only storage environments available are D/H warehouses and open air. If the compressors were domestic treated and stored in a D/H warehouse, the storage cost for the stateside unit is $28. The storage cost for the overseas unit is $28 plus the added cost of $31 for boxing, $36 for preserving prior to deck shipping and depreserving at destination. The overall cost for the two compressors for a 50-50 split then becomes $123 ($28 + $95). If they were contact preserved and stored in the same warehouse, the overall cost is $144 (2 x $72). If D/H warehousing is not available and the compressors must be stored outside, the overall cost is $229 for domestic treatment and $224 for contact preservation. Stateside storage cost is $28 and averaged with the total overseas cost, is $61.50. Contact-preserved storage cost is $52 in either D/H storage and depreservation cost is $20. The total is $72 regardless of destination.

Thus for the above example, it would be cheaper to select the D/H warehouse - domestic treatment combination. Table 14 gives the various overall costs of the compressor set under the hypothetical 50-50 split with all 5 types of storage environments available. The storage period is 30 months.

Table 14. Hypothetical Final Cost of Domestic and Contact Treated 30-Cfm Compressor

Type of Storage	Protective Treatment	When Overseas Portion is Stored Overseas (Deck & Hold Shipment)	When Overseas Portion is For Immediate Overseas Use	
			Deck Shipment	Hold Shipment
50 & 40% RH Warehouses	Domestic	102	123	119
	Contact	124	144	144
Standard Warehouse	Domestic	134	155	151
	Contact	172	192	192
Shed	Domestic	174	195	191
	Contact	184	204	204
Open Air	Domestic	208	229	225
	Contact	203	224	224

One facet of this problem which is not within the scope of this study, but which should certainly receive some serious attention is the possibility of dehumidifying ships' storage compartments. Such dehumidification might reduce the overall cost of having equipment in readiness for use.

f. Discussion

There are costs incurred in field storage of materiel not included in this cost analysis. Some of these are: price of land, shelving, power for lights, and guard costs. If the data are extrapolated to a large scale operation and different geographical locations, these should be considered. As mentioned earlier in the report, depreciation cost is not included. In the event materiel to be stored is of such a nature that this should be considered, the formula could be readily modified.

Most of the data used in the economic analysis was provided by the CED, CBC, Port Hueneme, California. The CED has indicated by letter (Appendix G) that these costs are substantially correct. However, it is pointed out that the NCEL cost formula is not in consonance with the practice and mission of the CBC. The following is quoted from that letter:

> "It has been noted that the present application of the cost figures in the NCEL Cost Formula is divergent from not only the CBC mission but normal operating procedure at this Center. The purpose of the Quality Control program at this Center, as outlined in TP-QC-1, is to provide at all times a maximum assurance of readiness and reliability of materiel stocks, and to assure that such stocks are maintained at all times in serviceable and ready for issue condition. To this end inspection and preservation procedures are followed which minimize the possibility of equipment deterioration between normal inspection cycles. In addition, any deficiencies discovered are repaired upon detection or as soon as possible thereafter."

That is, the NCEL method of obtaining rehabilitation cost will indicate a different cost than will actually occur in the field under present field practice. This is because in the field, rust is removed as soon as possible after detection, and thus involves extra handling of equipment. However, this added cost is offset to some degree by having only light rust to remove. As an example of the extra handling, if rust is discovered at the 3-month inspection in the cylinder wall of a jeep, all jeeps in the lot are taken to the shops and their engines represerved. Then, if at the 6-month inspection rust is discovered on a brake drum, all jeeps of the lot are again taken to the shops and all brake systems represerved. This cycle is repeated whenever rust is found, and could continue throughout the storage time.

In general, the difference between Laboratory and field practice is not important since there was no rehabilitation required for items in the D/H warehouse and little in the standard warehouse. However, the difference based on the TP-QC-1, is most pronounced on domestic-treated items in the shed and open air where rusting is the most severe. In these cases, Laboratory figures, which are believed to be conservative, show that this type of storage is more expensive than other methods for all items except Group V equipment. If the equipment must receive contact preservation, the Laboratory method of permitting rusting to occur unchecked for longer periods indicates open-air storage is cheapest. Further study will have to be done, however, to determine if this is true when the field method is used. From a purely economic standpoint, however, the NCEL analysis of data does expose those areas where major storing expenses occur so that they may be viewed in their proper perspective. For example, it was discovered that even in open-air storage where rusting was the most severe, the rehabilitation cost was not the largest contributor to the total cost. The largest single expense of open-air storage is the frequent inspections which it requires. By being awa'e of the predominate costs for the various types of storage, it will be known where to make the best attempts to economize whenever revisions to the present storage program are made.

As shown previously, maintaining items in a rust-free condition is not always the most economical method for storage. For some types of items, a "ready-for-issue" condition is possible only for a price. For other types of items, a rust-free, "ready-for-issue" condition comes as a bonus since D/H storage is also the most economical.

In performing studies of this type under actual field conditions, time becomes an important factor. Will there be time to apply contact preservation? When is mobilization most likely? Will the materiel be withdrawn before an emergency breaks? If all the factors concerning storage are readily available, storage programs can be tailored to fit the prevailing situation, thereby achieving the best results at the lowest cost.

SUMMARY OF RESULTS

The following results, based on information obtained over a 2-1/2 year period, are only valid under the test conditions. Sensitivity checks have determined, however, that a certain amount of extrapolation can be done without undue distortion.

1. No rust or corrosion has been discovered on equipment while stored in 40% and 50% controlled humidity warehouses.

2. Irrespective of preservation level, rust and corrosion occurred most in open air storage, less in the shed, little in the standard warehouse, and none in controlled humidity warehouses.

3. Contact-preserved items in the open air and shed had 58% fewer rust areas than the domestic-treated items. Contact-preserved items in the standard warehouse had 50% fewer rust areas than the domestic-treated items.

4. Except for automotive and non-metal equipment, items that will eventually be removed from storage to go overseas are cheapest to store if contact preserved and in a 50% RH warehouse.

5. Except for automotive and non-metal equipment, items that will be eventually removed from storage for immediate stateside use are cheapest to store if domestic treated and in a 50% RH warehouse.

6. Domestic-treated automotive and non-metal equipment can be stored cheapest in a standard warehouse. Contact-preserved automotive equipment can be stored cheapest in a standard warehouse. Contact-preserved non-metal equipment can be stored cheapest either outside or in a shed.

7. The Navy standard 40-ft x 100-ft rigid frame metal building has been satisfactory with limited modifications as a dehumidified warehouse during 2-1/2 years of use.

8. For the outside environment encountered, the D/H machine in the 40% RH building operated twice as long as the one in the 50% building, and thus used twice the power.

CONCLUSIONS AND RECOMMENDATIONS

1. Under the present TP-QC-1 requirements, the mobilization reserve apportioned stock must be ready for overseas shipment during the initial phase of any naval emergency. These reserves must be contact-preserved beforehand because there might be insufficient time to do so in the event of an emergency. Therefore, by using the results of the economic analysis as a guide, the most economical way to store various types of mobilization reserves can be determined.

2. While it is well to bear the extra expense of maintaining equipment necessary for security of the United States in a condition that is rust-free and ready for overseas shipment, maintaining additional equipment in this condition is unduly costly. For non-emergency items or items for stateside use where the time-lag between removal from storage and usage is short, the least costly methods of storage as shown by the economic analysis should be seriously considered.

3. If a study could be made of the usual time-lag of various items going overseas, limited contact preservation could be applied to protect items during the time of exposure before being used. In this way, items could be domestic treated, stored in a 50% RH warehouse (which is the cheapest for most items), and then shipped with only the necessary preservation. The preservation could be applied at any time during storage since results show that D/H storage does not harm preservatives. The preservation might even be applied enroute.

4. Since no rust has been detected on the items stored in the D/H warehouses and only modest amounts in the standard one, it is believed that inspection frequencies for these conditions could be lengthened. This would lower the overall storage cost, and the cost analysis might indicate a different pattern of results.

5. An advantage of D/H storage is that if an item has rust when put into storage (from faulty preparation, delays in getting into the warehouse, etc.), growth of the rust will be stopped. All other conditions permitted rust growth.

6. Since it is twice as costly to maintain a 40% RH level than a 50% RH level, and since no rusting attributable to these environments has been detected, it is concluded that a 50% RH level is suitable for a period of at least 2-1/2 years.

7. The Navy standard prefabricated 40-ft x 100-ft metal building is considered suitable for advanced base dehumidified storage if the louvers and windows are eliminated and the fit tightened around the cargo door. A building which has fewer joints would be more desirable.

8. Sealing of the 40-ft x 100-ft metal building should be determined on an individual basis since the economical break-even point will vary with the factors of building tightness, geographical location, power and labor costs, and desired relative humidity level. By comparing the prevailing situation with that of Port Hueneme, a good estimation of sealing requirements can be obtained.

9. It is impossible to conclude that there is any one best method of storage. To achieve the lowest possible cost, a number of things must be considered about each item in storage: (1) Overseas or stateside destination; (2) Degree of necessary readiness; (3) Time-lag between removal from storage and actual use; (4) Weather conditions at storage site; (5) Labor costs at storage site. With consideration given to these factors, the economic analysis in this report can be used to determine the most economical storage method. If building limitations prevent the most economical method from being used, the least expensive method of the available alternatives can also be determined from the economic analysis.

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NCEL ltr Report E-LR-23, 2nd Quarterly Inspection of Open Slab and 1st Semi-Annual Shed Inspection, R. J. Zablodil, 8 March 1956.

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NCEL ltr Report E-LR-43, Annual Normal Warehouse Inspection, R. J. Zablodil, 25 March 1957.

NCEL ltr Report E-LR-44, 5th Open Slab Inspection, R. J. Zablodil, 8 April 1957.

NCEL ltr Report E-LR-46, Annual 50% RH and 40% RH Warehouse Inspection, R. J. Zablodil, 22 April 1957.

NCEL ltr Report E-LR-51, 3rd Six Month Open Shed Inspection, R. J. Zablodil, 10 July 1957.

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Mr. J. A. Young, director of the Quality Control Division, and Mr. S. N. Slebiska, manager of Preservation Process Branch of the Quality Control Division, and their staffs, Construction Equipment Department, CBC, Port Hueneme, California, devoted considerable time and effort to provide costs and storage procedures information. The authors wish to express appreciation to these gentlemen for their cooperative assistance, for without it much of the information concerning storage cost analysis could not have been properly prepared.

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Acknowledgement is also extended IBM personnel for their invaluable assistance in initiating the cost analysis program and providing continued consultation.

APPENDIX A

TYPES OF EQUIPMENT IN STORAGE

Following is a list of the items, with SNS numbers, that are in the storage test. In each environment there are two of each item; one domestic-treated and the other contact-preserved. The open-air and shed environments each contain 19 pairs of items, and the remaining environments contain 29 pairs.

A. Equipment in Open Air & Shed	SNS No.
1. Boiler, vertical, 180,000 Btu	4520-184-3708
2. Compressor set, air, 30 cfm	4310-L60-0089
3. Distillation unit, 83 gph	4620-185-0857
4. Generator set, diesel, 30 kw	6115-295-0973
5. Heater, space, oil-fired, 50,000 Btu	4520-200-0647
6. Machine, washing	3510-240-6552
7. Oven, bake	7310-275-6180
8. Pump, centrifugal, 350 gpm	4320-273-8574
9. Pump, diaphragm, 50 gpm	4320-132-5382
10. Refrigeration unit (675-6800)	4110-287-3184
11. Refrigeration panels for 6800 unit	4110-287-3179
12. Searchlight, 60 inch, with powerplant	6230-L60-0142
13. Tank, canvas, 3000 gallon	5430-222-1923
14. Tires, 8.25 x 20	Y8-T-9076
15. Trailer, floodlight, mobile	6230-283-9760
16. Transfer unit, CO_2	3655-245-0073
17. Truck, dump, 2-1/2 ton, 6 x 6	2320-835-8595
18. Truck, jeep, 1/4 ton, 4 x 4	2320-835-8317
19. Welder, arc, GED, trailer, 300 amp	3432-224-7722

B. Standard & Controlled Humidity Warehouses

These warehouses, in addition to the foregoing list of 19 items, have the following 10 items.

1. Chemical warfare detector kit	6665-L60-0123
2. Drill press, 18 inch swing	3413-L60-0001
3. Fan, exhaust, 4900 cfm	YS66-F-70020-50
4. Lathe, floor model, 14-1/2 inch swing	3416-174-1535
5. Public address system	5830-501-4724
6. Saw, radial, 16 inch	YL40-S-1365-200
7. Slicer, meat	7320-222-417
8. Switchboard, 50 line	5805-501-4725
9. Telephone system, 13 unit	5805-501-4726
10. Transit, surveyors	YZ18-T-3311-750

APPENDIX B

DESCRIPTION AND EXPLANATION OF COST FACTORS

A = The Labor Hours to Initially Prepare For Storage

Equipment to be stored is either domestic treated or contact preserved. Domestic treatment is furnished by the manufacturer and no additional preservation expense is incurred if the equipment is stored in this condition. But the equipment to be contact preserved must be partially disassembled, cleaned, preserved, and reassembled. This requires an expenditure of labor. The Quality Control Division, Construction Equipment Department, CBC, Port Hueneme, California, furnished information about the man-hours required to initially prepare the items for the NCEL test.

B = Material Cost to Initially Prepare For Storage

Similar to factor A, no material costs are incurred if the stored equipment is domestic treated; they are absorbed by the manufacturer. But to contact preserve requires cleaning solvents and preservation materials. Articles such as rags, gloves, brushes and spraying equipment are not included, for their cost prorated over each individual item would be insignificant. Material costs to initially prepare for storage were obtained from the Quality Control Division.

C = Square Footage Required For Storage

The area allotted to each item is based on current warehouse tiering and palleting and service space procedures. Service space, such as aisles, fire breaks, receiving and shipping space, etc., has been set at 40% of the total floor area in a 200-ft x 600-ft warehouse storing equipment similar to that of the NCEL test. A factor of 1.67 is thus used to determine the total space needed for a test item. If an item covers 6 sq ft of floor area, it needs 10 sq ft (6 x 1.67); however, if a similar item is tiered on top of the first then the space allotment is 5 sq ft per item. The same procedure is followed with palleted items.

D = Unit Fixed Cost of Storage Per Square Foot Per Month

Except for the original price of land, this factor takes into account all initial costs of the environment amortized over a certain period of time. Included are such expenses as building costs, labor costs, supporting machinery costs, and the like. The standard 40-ft x 100-ft prefabricated metal building was bought for $4770 in 1955, and the catalog price for this building has not yet increased. The cost for building foundation, slab, and erection are based on 1959 prices. These figures have been increasing at the rate of 3 to 4 percent annually, and this increase should be considered when developing the factor D. Factor D for each test environment is given below, but for a complete listing of all costs and amortization periods see Appendix E.

1. Open Slab	$.0063 /sq ft/ month
2. Shed	$.0108 /sq ft/ month
3. Standard Warehouse	$.0123 /sq ft/ month
4. 50% & 40% RH Warehouse	$.0141 /sq ft/ month

E = Storage Maintenance Cost Per Square Foot Per Month

This factor takes into account such maintenance and operating expenses as painting (every 3 yrs), power, and maintenance costs of dehumidifying machinery. Not included are taxes, guard costs, and insurance costs. Factor E for each test environment is given as follows:

1. Open Slab	$ 0 /sq ft/ month
2. Shed	$.0050 /sq ft/ month
3. Standard Warehouse	$.0063 /sq ft/ month
4. 50% RH Warehouse	$.0094 /sq ft/ month
5. 40% RH Warehouse	$.0102 /sq ft/ month

F = Labor Hours for Item Inspection

Inspection labor hours upon which this factor is based are determined from the CBC, Port Hueneme, time-cost accounting records. These are records of the actual time required to make the equipment inspections at the times specified by the Quality Control Procedures Manual TP-QC-1. These times, when averaged, become reliable statistical data. Note that the periodic inspections of test items mentioned earlier in the report are for the purpose of determining the state of deterioration only and are not included in factor F.

G = Labor Hours For Operational Testing Only

There are two parts to the operational tests specified in the TP-QC-1. One part tests equipment in dead storage, and the second tests new receipts for acceptability.

Dead storage equipment need not be tested if class I and II inspections are satisfactory. Thus, operational tests at Port Hueneme are not made. Operational test costs were included in this analysis, however, because the adequacy requirements of class I and II inspections may in time vary, and because the standards for adequacy may vary at each CBC depot. Representative costs were furnished by the Quality Control Division of CED, Port Hueneme.

Costs of acceptability tests for new receipts are not included in this analysis.

H = Labor Hours for Depreservation

Before contact-preserved equipment can be placed in service, the preservation material must be removed. If the equipment is to be used stateside, the preservatives are generally removed by the Center issuing the equipment. If the equipment is to be shipped overseas, the preservative material is generally left intact for the receiving station to remove. But regardless of who removes the preservative, the removal is a chargeable storage cost. Similar to factor E, labor hours for removal have been obtained from time-cost accounting records. Depreserving domestic-treated equipment is not necessary since this equipment is stored with service oils and greases and in a ready-to-use condition.

i = Subscript

denoting "With respect to type of storage environment."

j = Subscript

denoting "With respect to particular item stored."

K = Ratio of Sample Size to Lot Size

Actual periodic field inspections are made on random samples; the number of samples required for inspection is specified by the TP-QC-1 manual. For example, in 25 jeeps, 5 must be inspected. This gives a sample to population ratio of 1:5 which is used in the basic equation. This ratio, however, will vary with different lot sizes, with the percentage of samples decreasing as the lot size increases. In a lot of 2 to 8 items, the sample size would be 4, but for a lot of 66 to 110 items, the sample size would be 7.

L = Hourly Labor Charge

This is the average hourly rate paid to employees associated with the preservation and storage of equipment. The average current rate at CBC, Port Hueneme, $2.60 per hour, is the rate used in the formula.

M = Rehabilitation Costs

This estimates the cost of restoring each piece of material to an issuable condition at any given time during storage tenure.

For materiel in open air, rehabilitation costs were estimated from records of class III inspections performed after 30 months of exposure. Experienced CED personnel made these estimates.

Materiel sheltered in shed, standard, and D/H warehouses will receive class III inspections after 5 years of exposure. To overcome the lack of actual corresponding data and to estimate rehabilitation costs at 30 months, NCEL and CED engineers extrapolated rusting from:

a. Class II inspection records at 30 months
b. Probable undetected rust in uninspected areas as determined from class III inspection records of similar equipment exposed to open air.

Costs for periods of less than 30 months were obtained by applying the following proportion:

$$\frac{\text{Rusting index (open)}}{\text{Rusting index (shed or std)}} = \frac{\text{Rehabilitation cost (open)}}{\text{Rehabilitation cost (shed or std)}}$$

The rusting index is then adjusted to the magnitude of the rust count curve for the appropriate environment and preservation level.

At the end of five years of storage, all items will be given a class III inspection and exact rehabilitation costs will be computed at that time. The above estimates used for extrapolating rehabilitation costs will be checked for accuracy and any adjustments necessary will be made in the final report.

N = Material Cost For Crating, Dunnage, Boxing, etc.

All items in storage except automotive equipment are boxed or crated. In general, contact-preserved items are boxed, and domestic-treated items are open crated. Boxes and crates can be stacked to conserve space, and boxes offer additional protection. Most service items are crated by the vender, and their cost is included in the original price of the items. Information about the cost of packing materials comes from the Supply and Disbursing Department, CBC, Port Hueneme, California, and is given in Appendix F.

P = Original Cost of Items Less Depreciation

To allow for the possibility that an item in storage could deteriorate beyond repair, the expression $S_{ij}P_{ijt}$ was included in the formula. If the item cannot be repaired, the remaining value of the item would be added to the storage cost. P should indicate the net value according to accepted accounting procedures of that type of item.

As long as the item is repairable, the S_{ij} which is multiplied by P in the equation, will be zero, and the expression drops out of the equation. If the item is beyond repair, S will equal one (1) and charge the loss to the storage environment.

S = One (1) If Item Is Found To Be Unrepairable; Zero (0) if otherwise

Use of this expression is included in the explanation of P.

t = Subscript denoting "With respect to time."

T = Storage Time In Months

This indicates in months the total time the item has been in any particular storage environment.

U = Number of Class II Inspections

The inspection frequency used for the cost calculation is presented in TP-QC-1. The number of inspections is the whole number obtained from dividing the storage time by the inspection frequency. No fractional parts of an inspection are used. For example, if an item with an inspection frequency of 6 months were stored for 21 months, the number of inspections computed would be 3, not 3-1/2.

V = Number of Operation Tests

The operational testing frequency used in the calculations is presented in the TP-QC-1 as every second class II inspection. No fractional part of a test is considered.

W = Total Cost

This represents the total cost in dollars for the storage of an item within the limits of the Laboratory test.

Y = Ratio of Operationally Tested Items to Lot Size

At every second class II inspection, an operational test is given to applicable items.

In the TP-QC-1, a "Sampling Plan for Operational Tests" table gives the number of items to be operationally tested for any given sample size. For example, out of five samples for a class II inspection selected at random from a lot of twenty-five items, four of the five items would be operationally tested. This example would have a ratio of four to twenty-five and was used in above equation; however, the ratio will vary with different sample sizes.

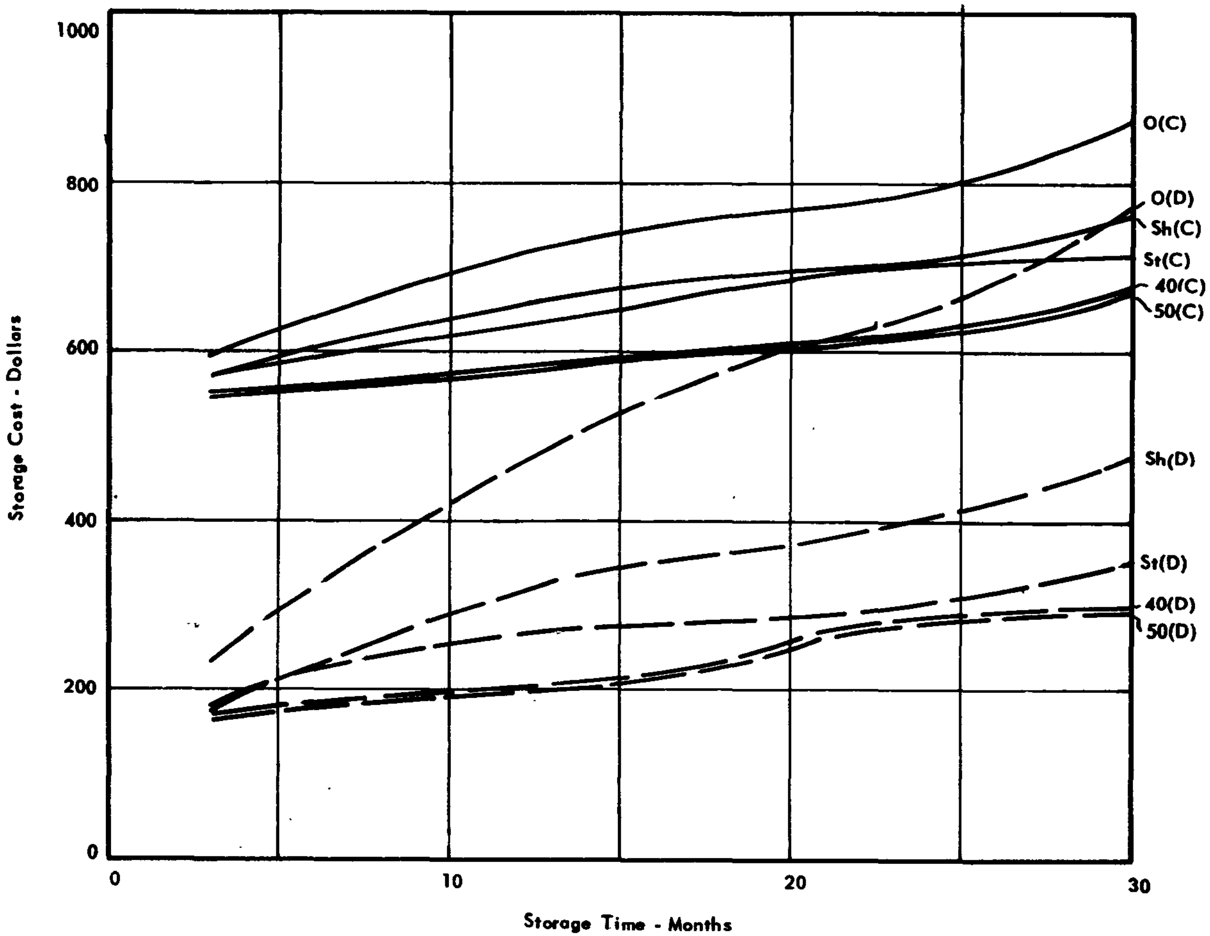


Figure C-1. Storage Cost Versus Storage Time for Group I Items.

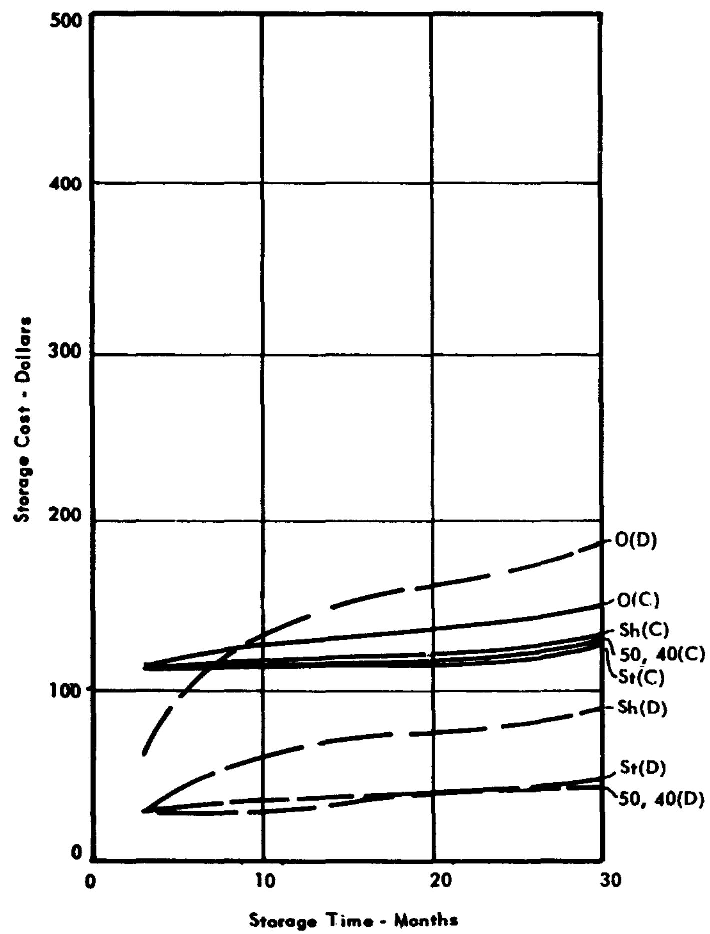


Figure C-1a. Centrifugal Pump 350 GPM.

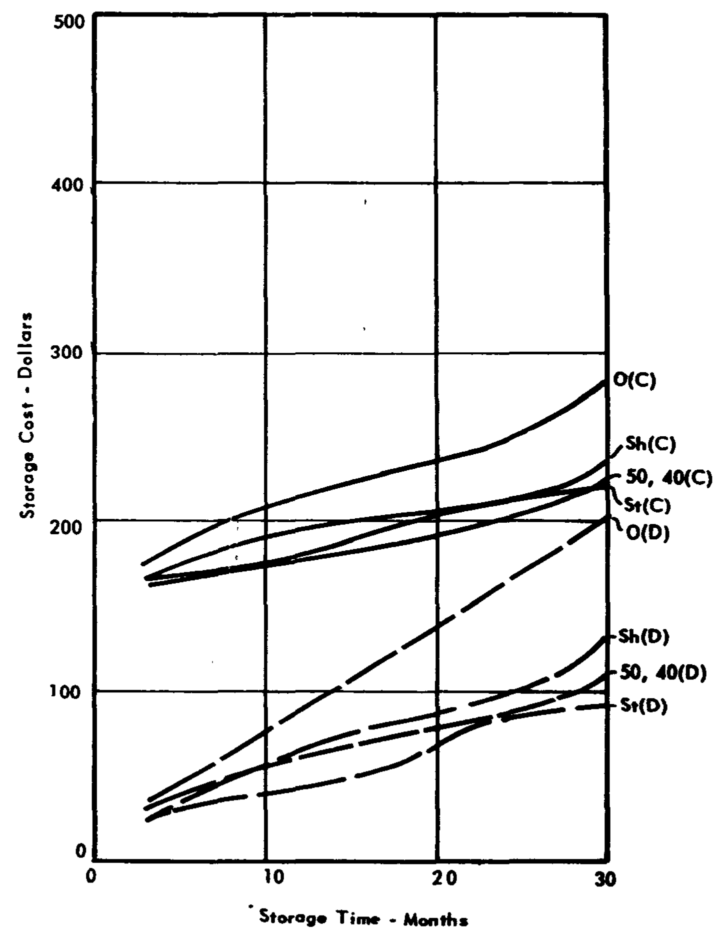


Figure C-1b. Distillation Unit 83 GPH.

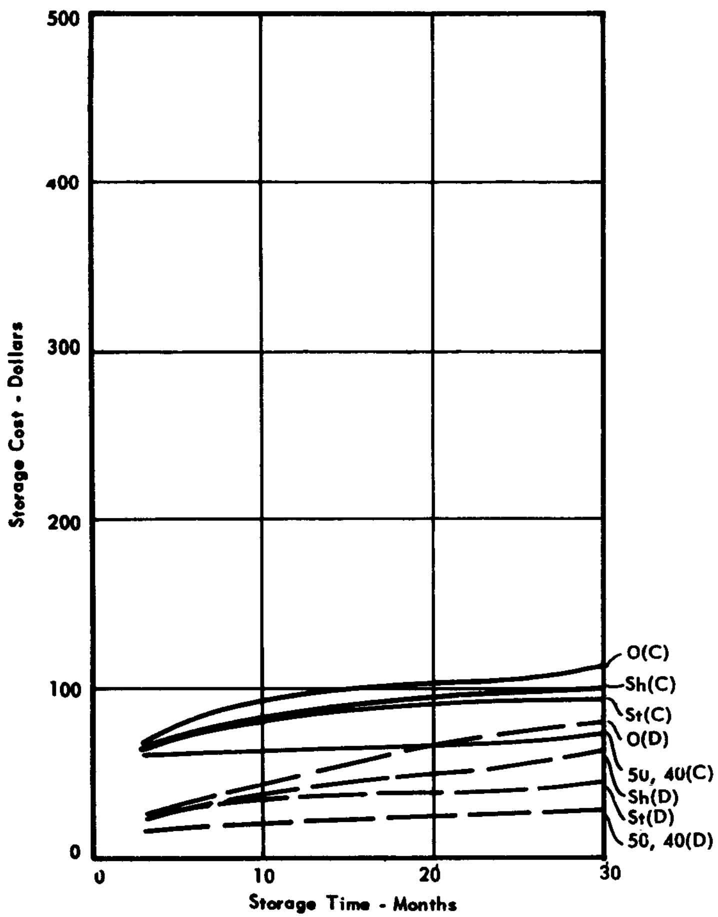


Figure C-1c. Compressor Set, 30 CFM.

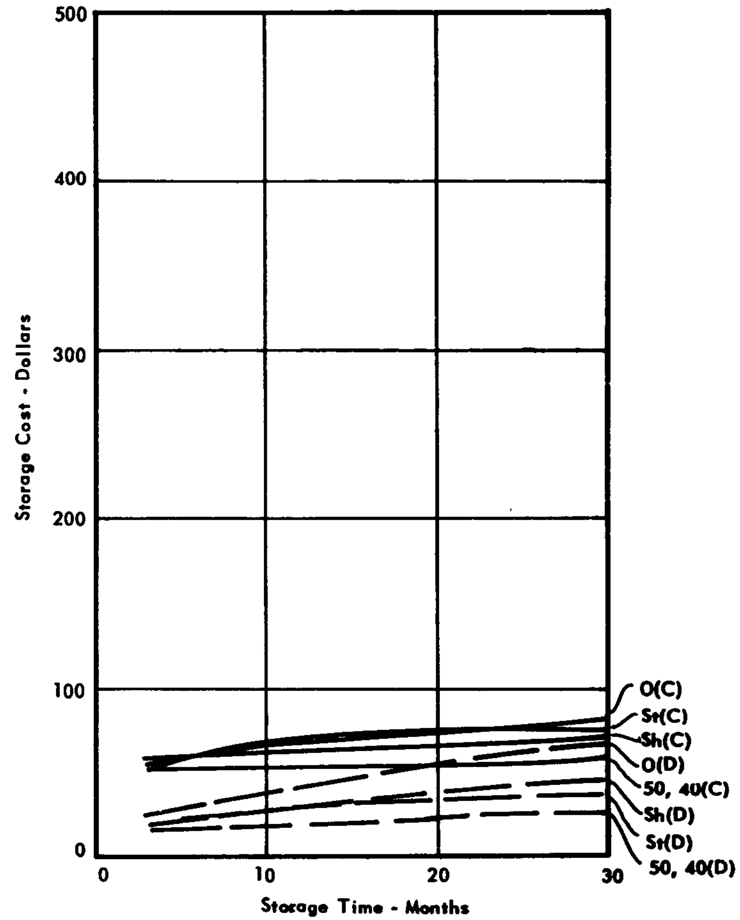


Figure C-1d. Diaphram Pump 50 GPM.

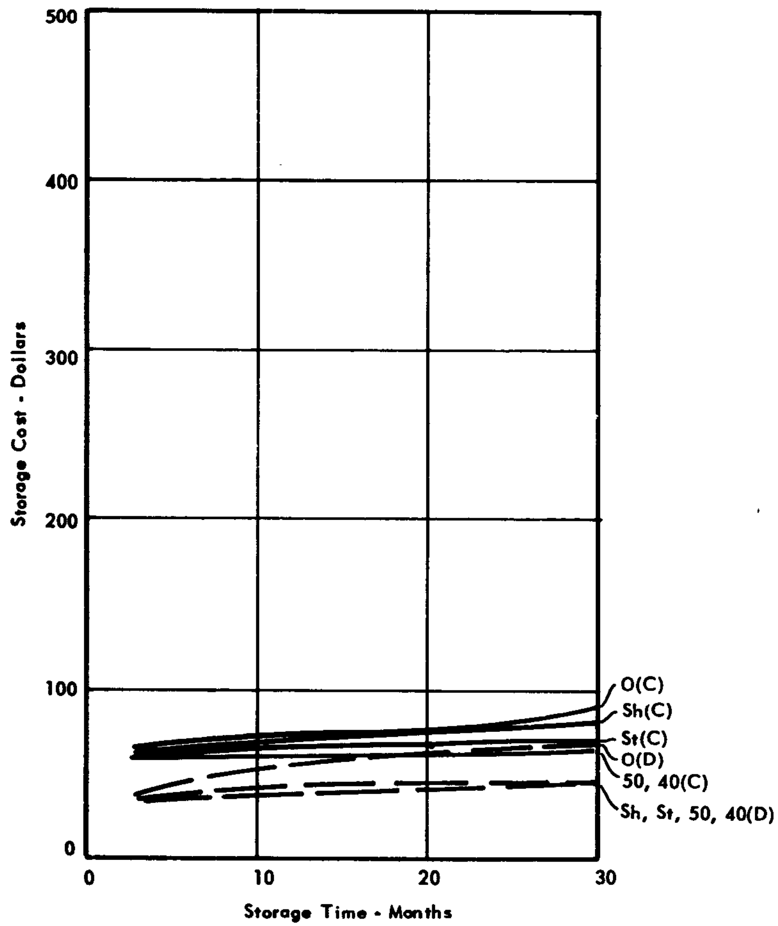


Figure C-1e. Machine Washing.

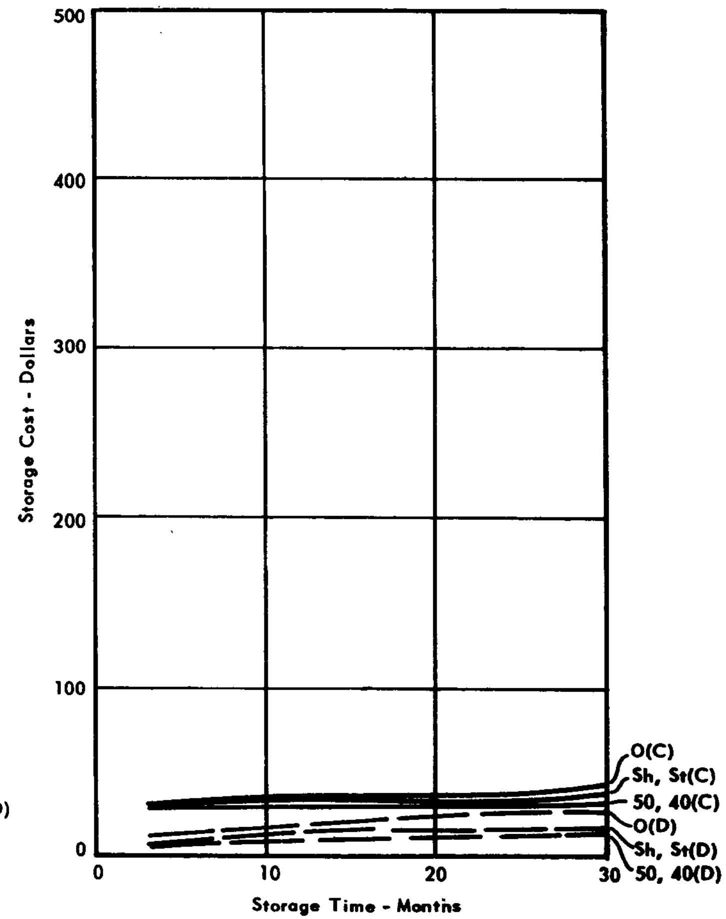


Figure C-1f. Transfer Unit CO_2.

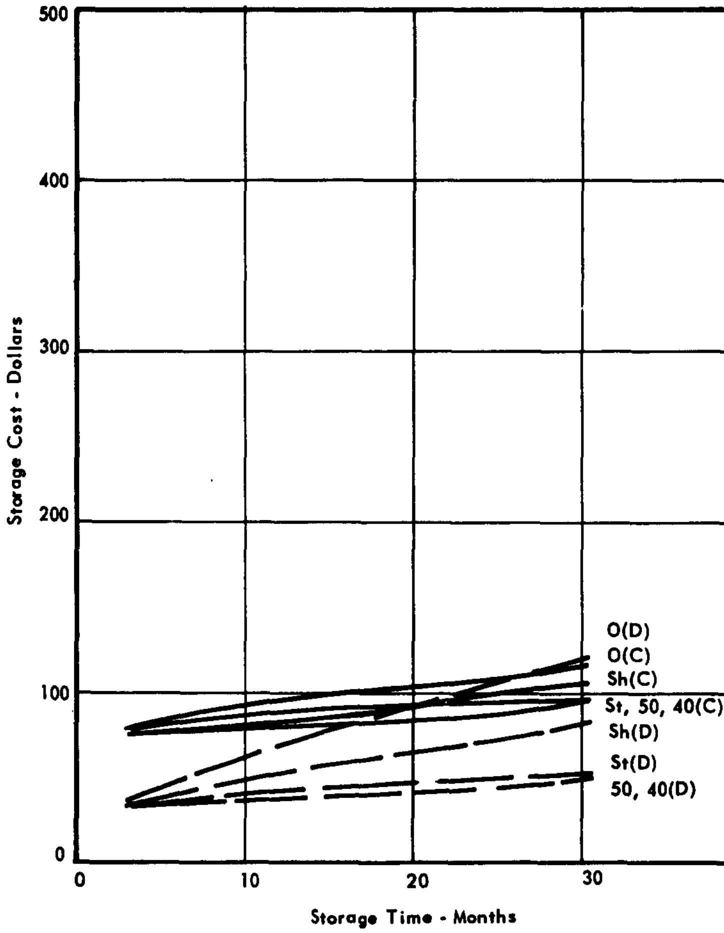


Figure C-1g. Refrigeration Unit.

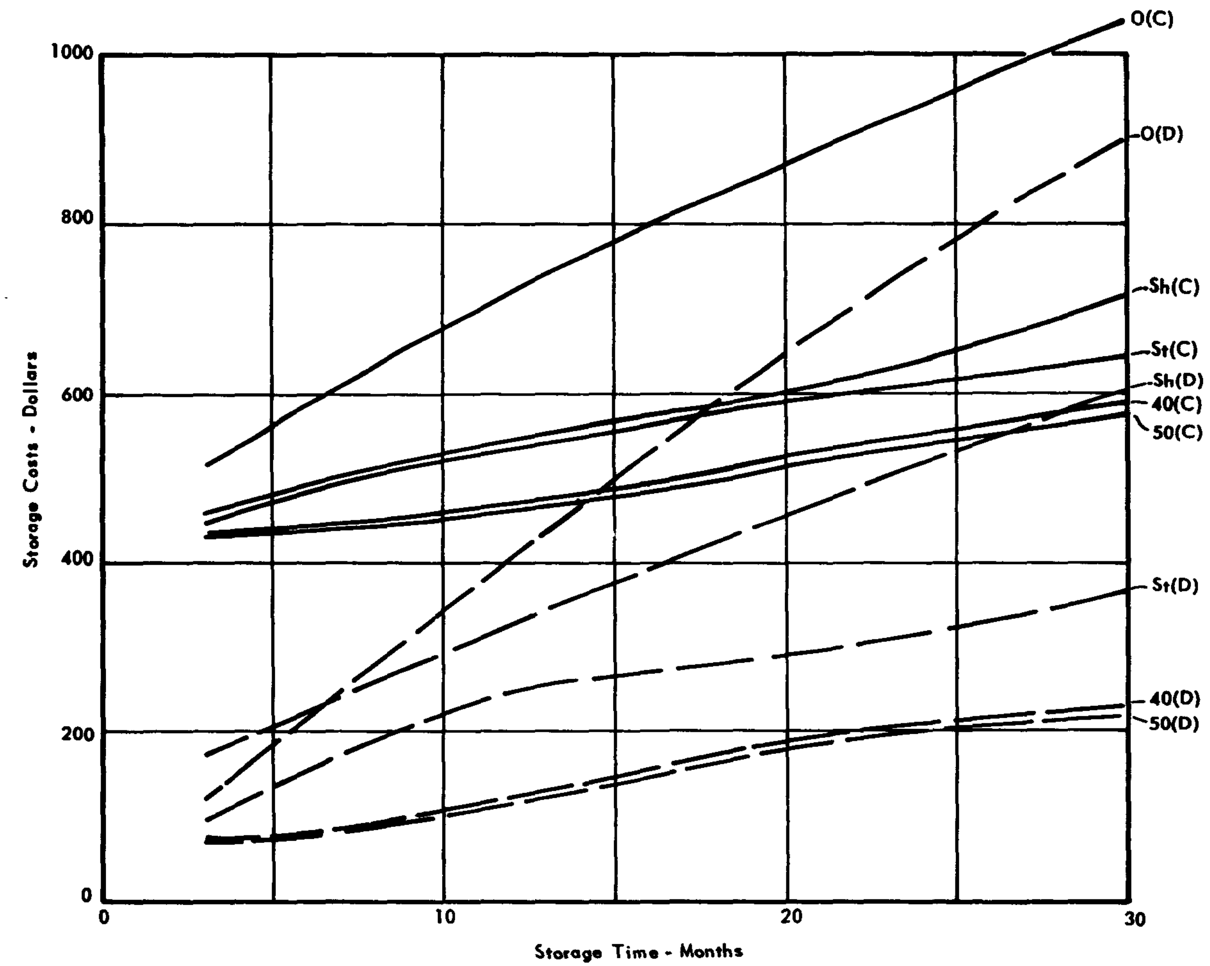


Figure C-2. Storage Costs Versus Storage Time for Group II Items.

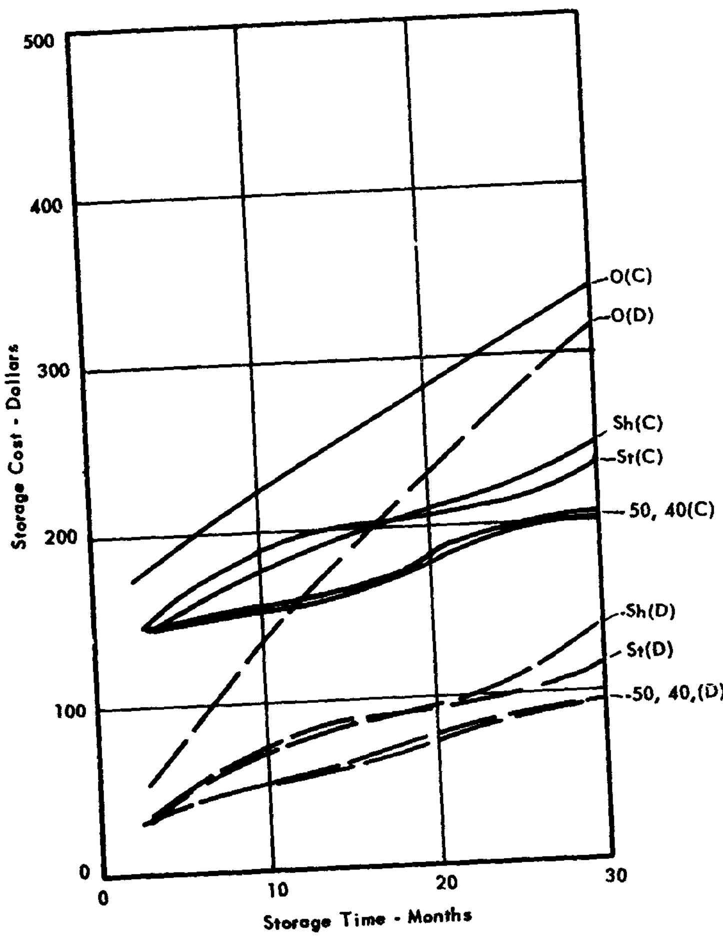


Figure C-2a. Searchlight w/Power Plant.

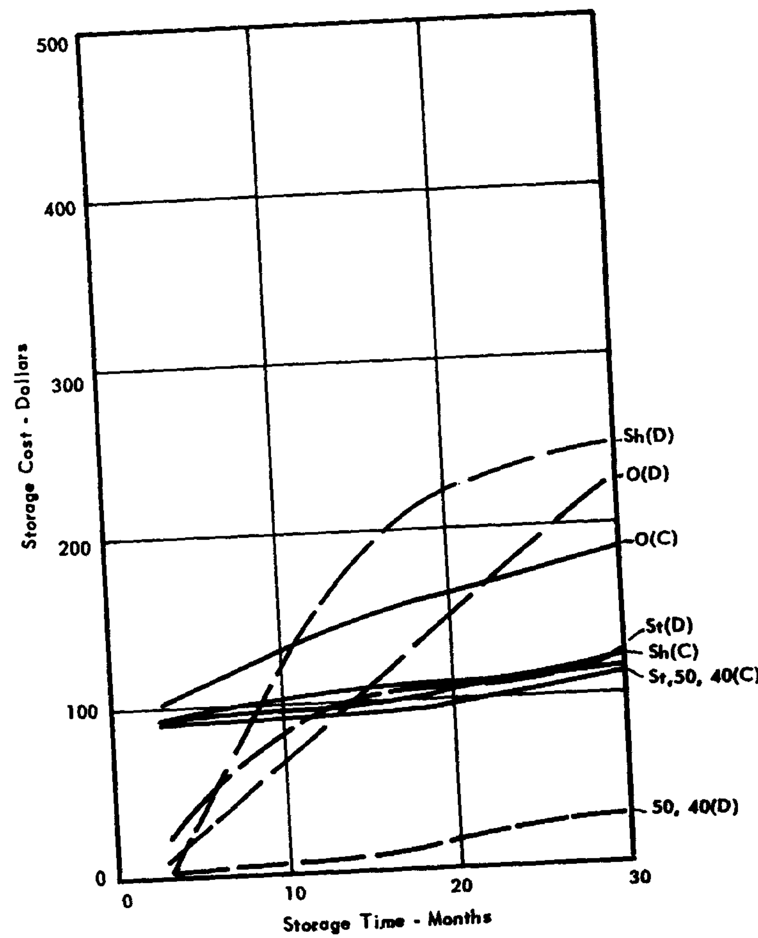


Figure C-2b. Welder, Arc GED Trailer.

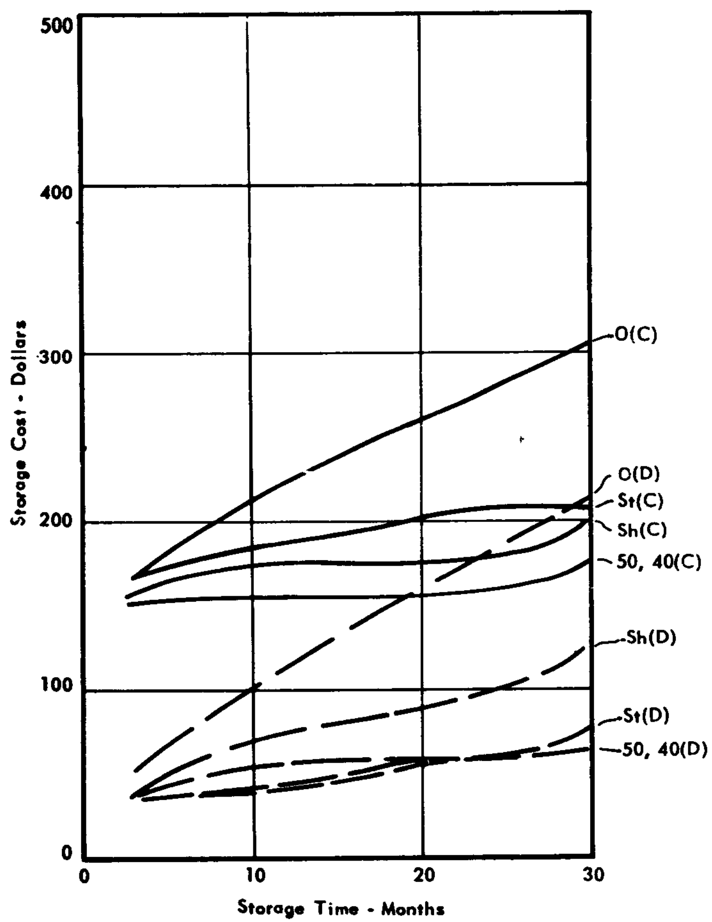


Figure C-2c. Generator Set 30 KW Diesel.

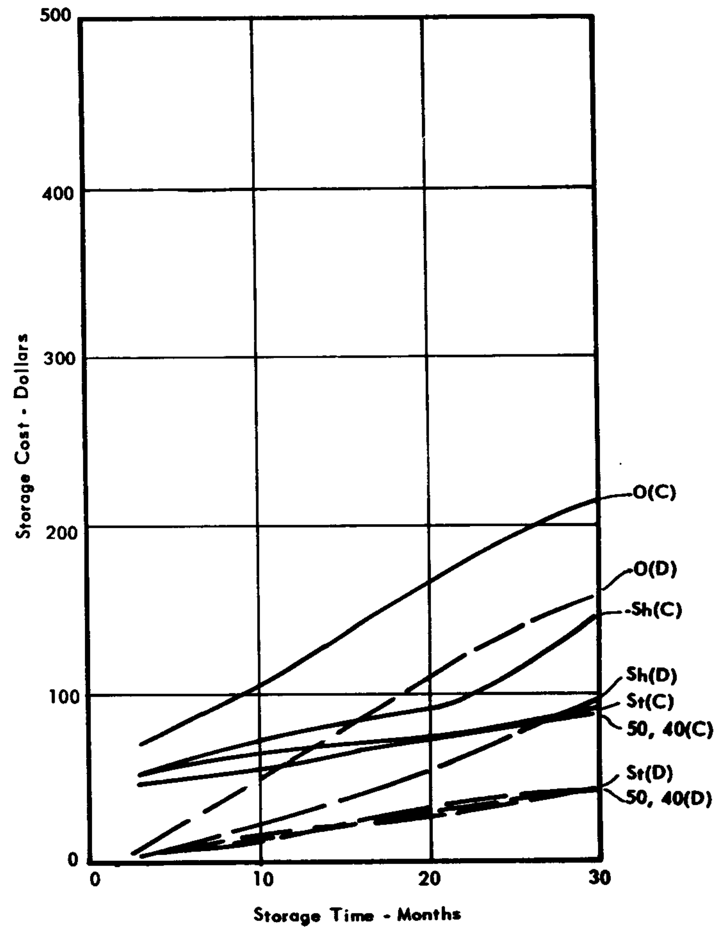


Figure C-2d. Floodlight Trailer Mobile.

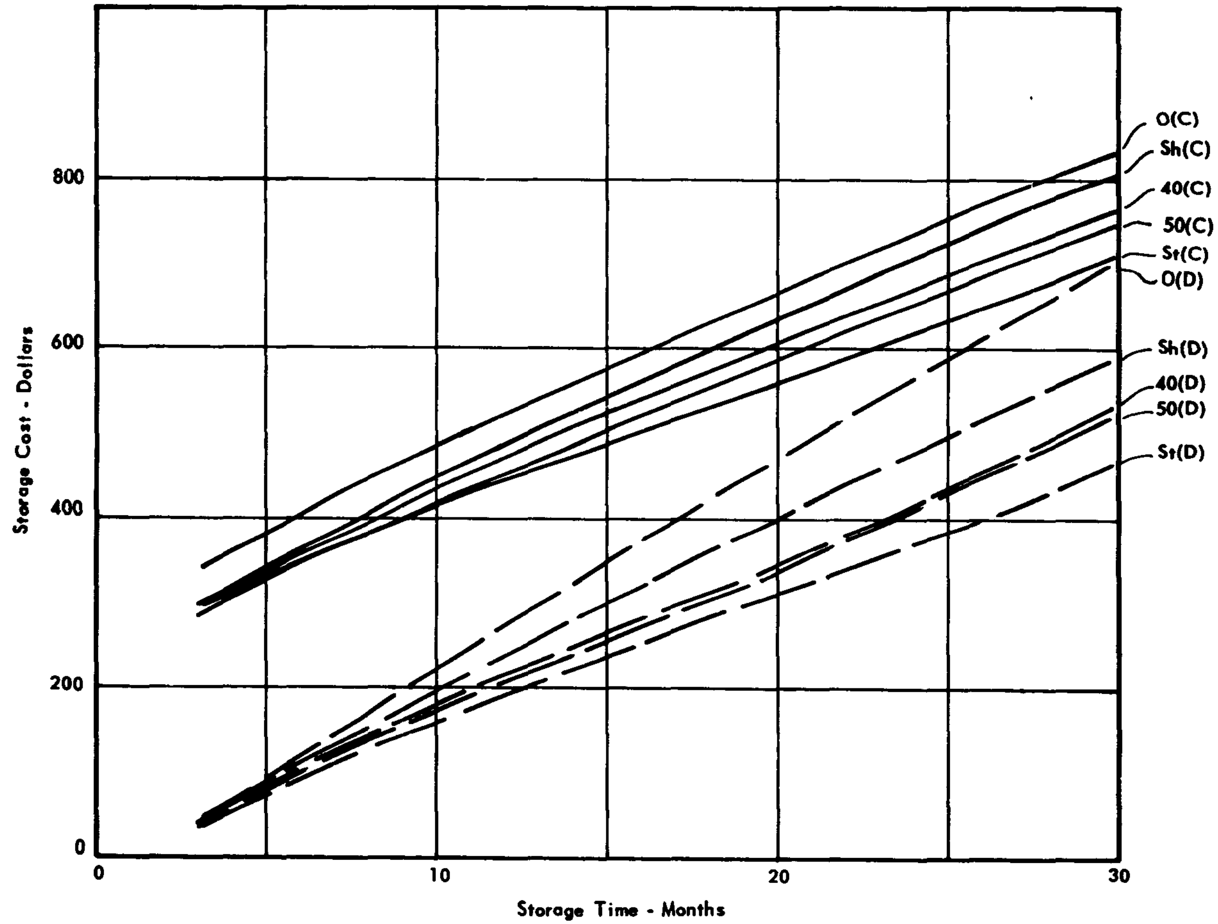


Figure C-3. Storage Costs Versus Storage Time for Group III Items.

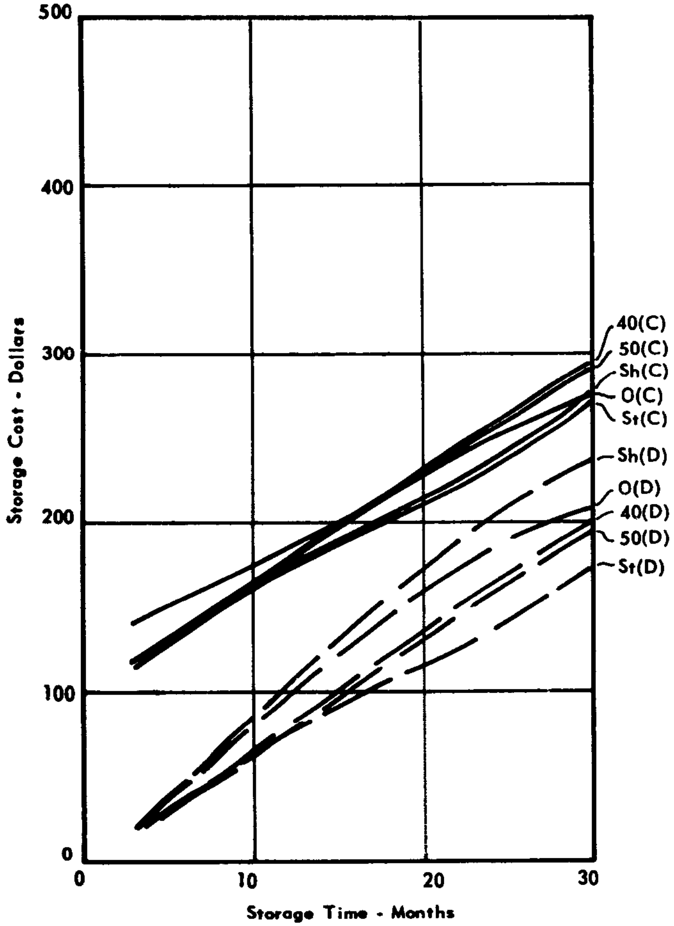


Figure C-3a. Truck, Jeep 1/4 Ton 4 x 4.

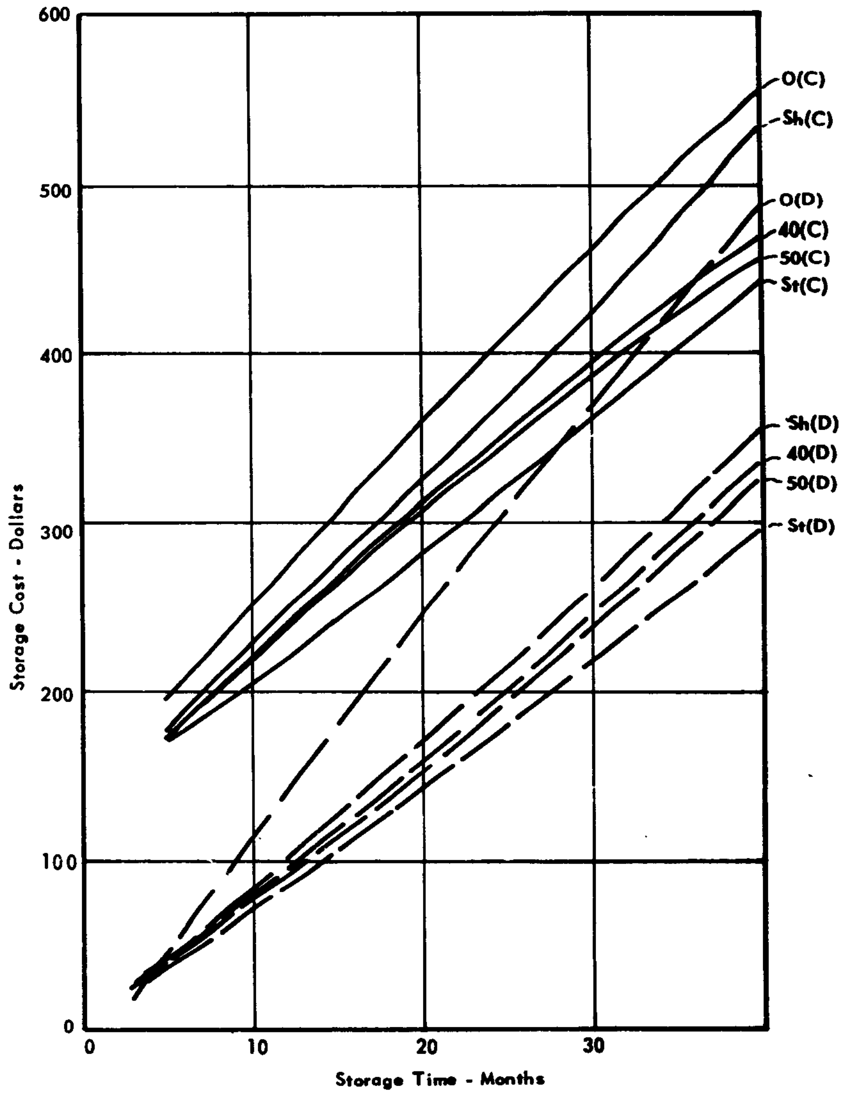


Figure C-3b. Truck, Dump 2-1/2 Ton 6 x 6.

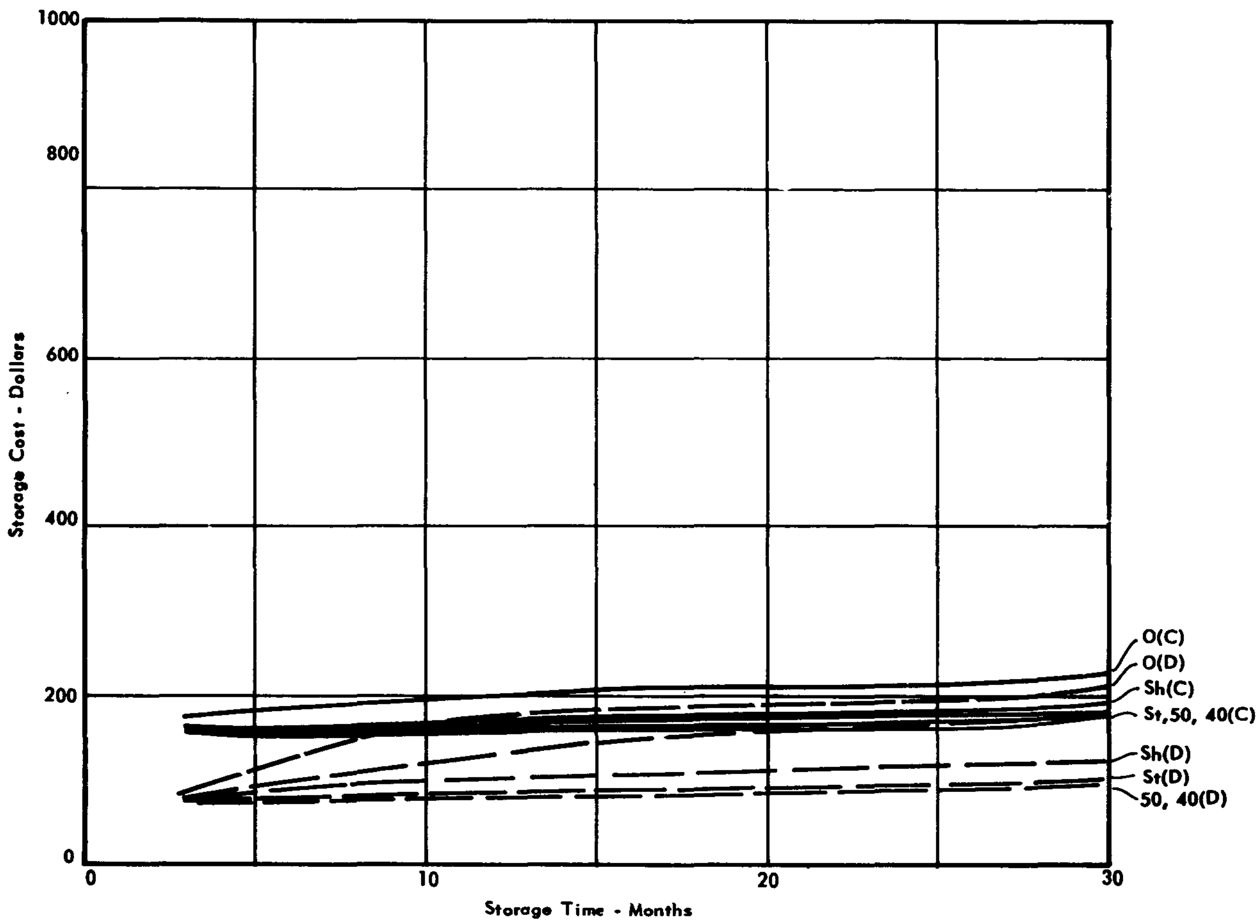


Figure C-4. Storage Cost Versus Storage Time for Group IV Items.

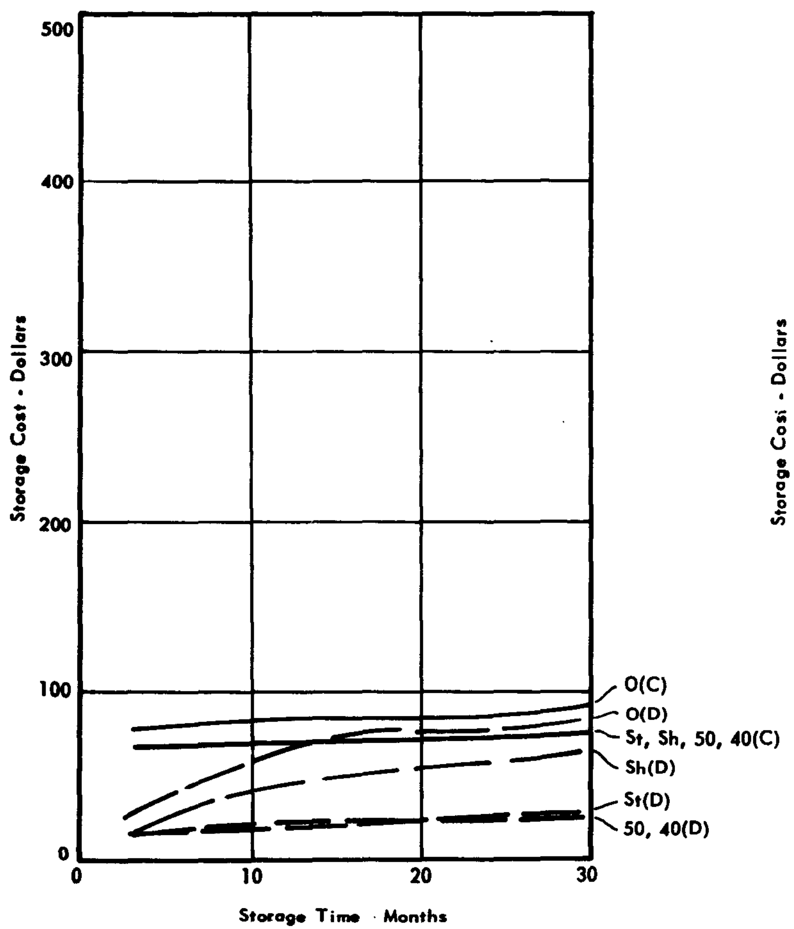


Figure C-4a. Boiler, Vert. 180,000 BTU.

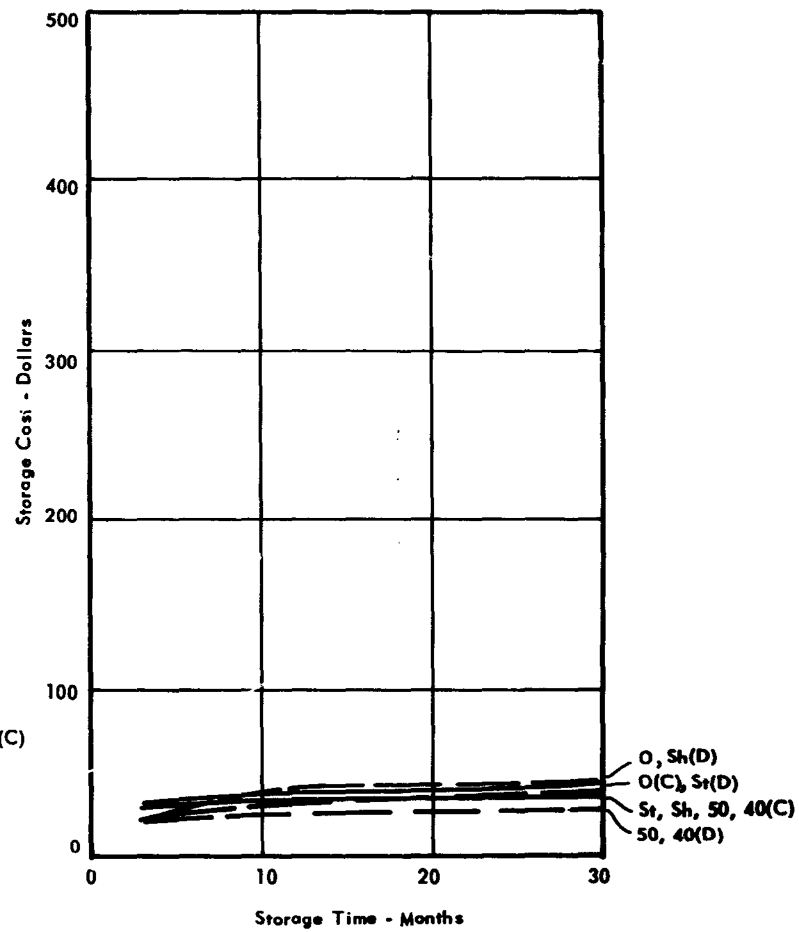


Figure C-4b. Heater, Oil Fired 50,000 BTU.

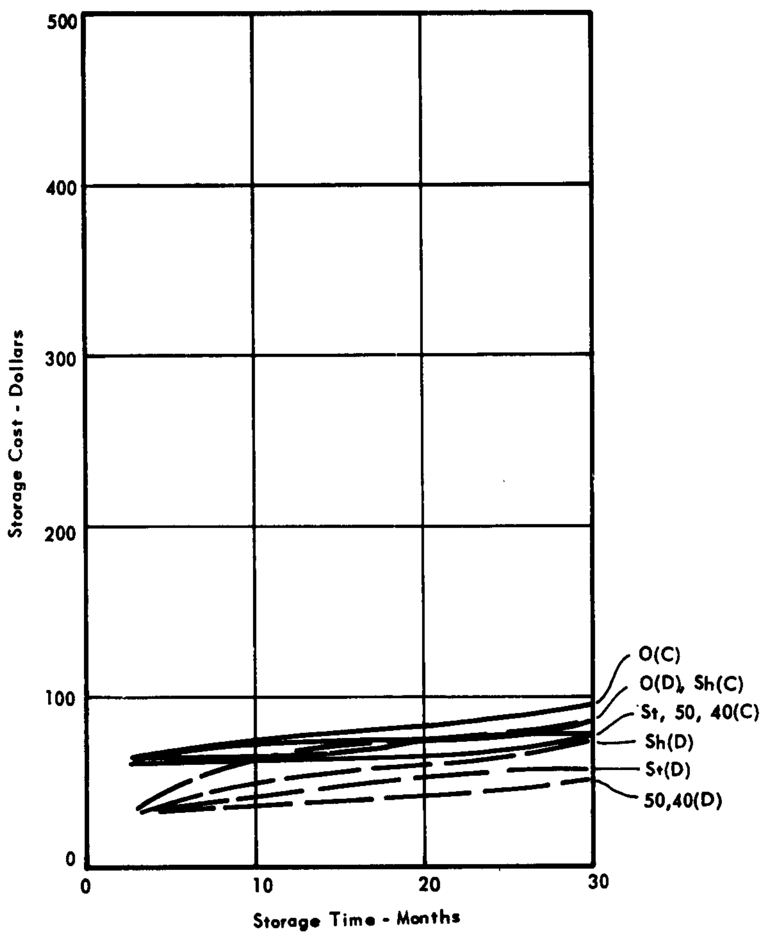


Figure C-4c. Bake Oven.

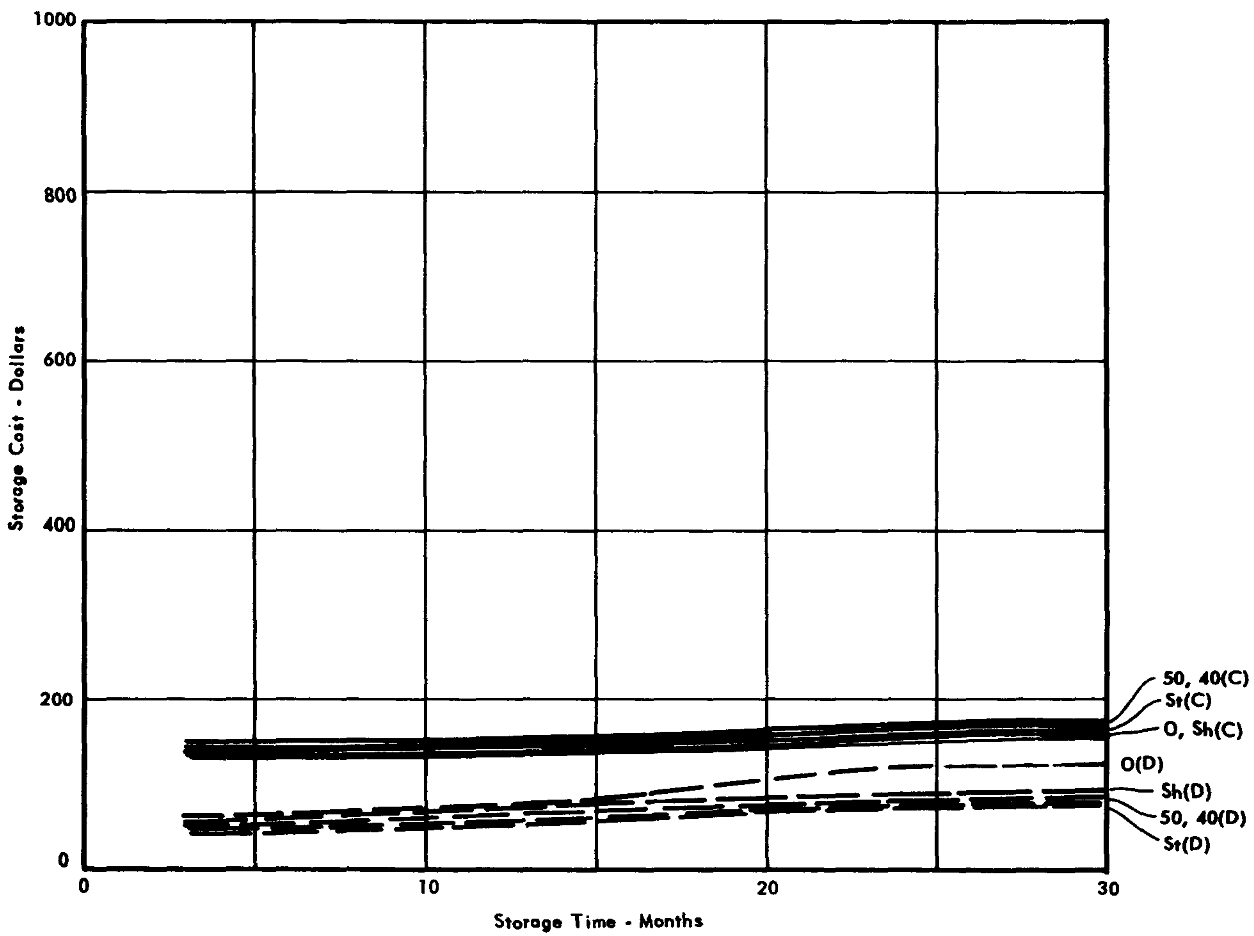


Figure C-5. Storage Cost Versus Storage Time for Group V Items.

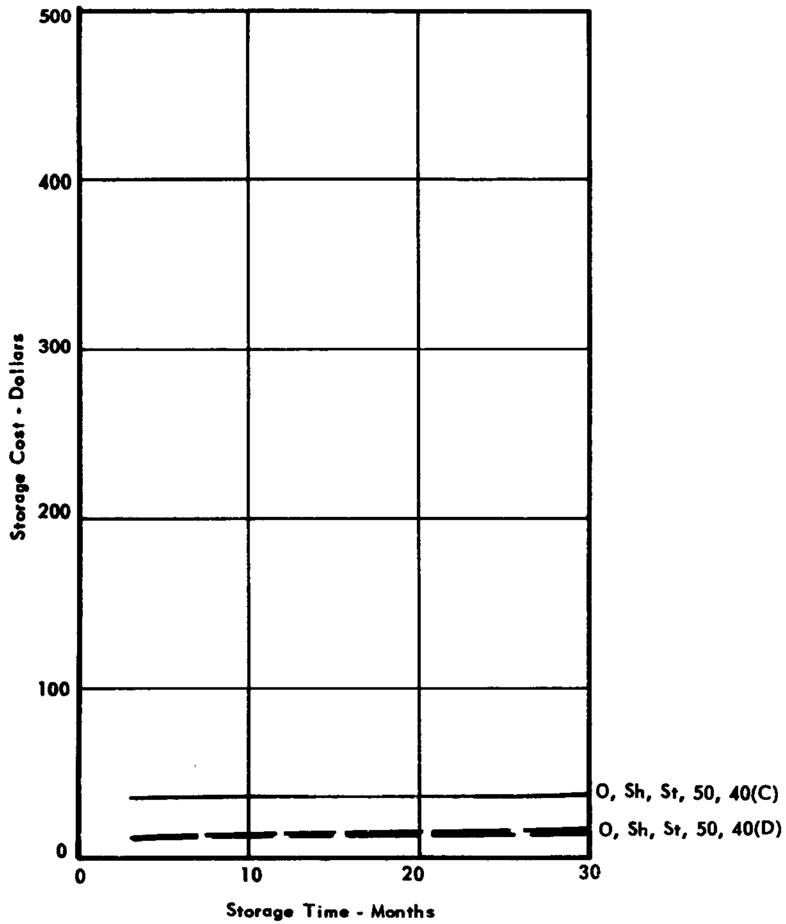


Figure C-5a. 3000 Gal. Tank Canvas.

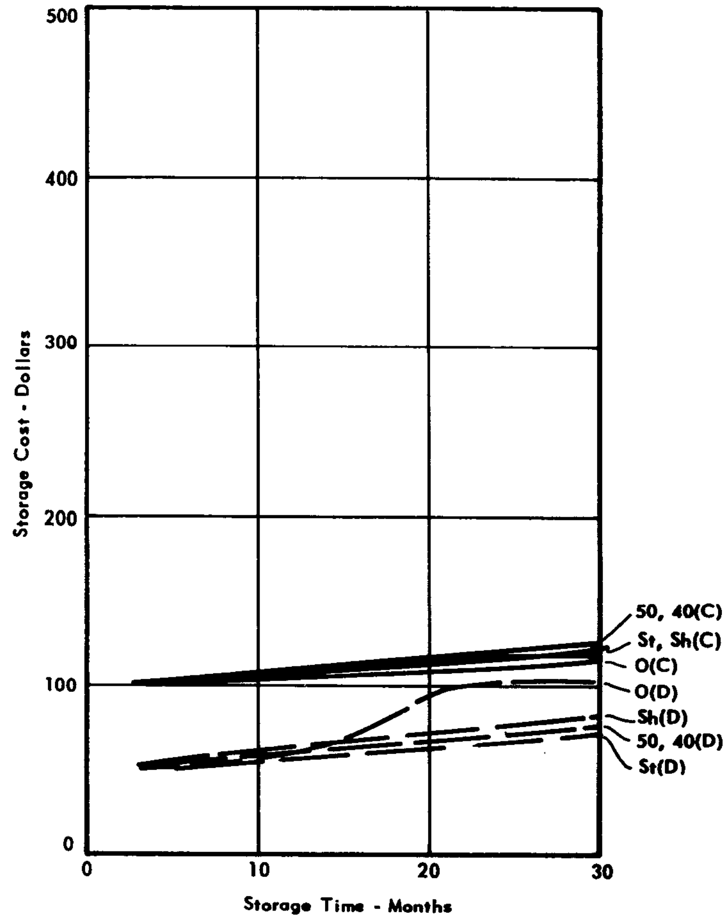


Figure C-5b. Refrigeration Panels.

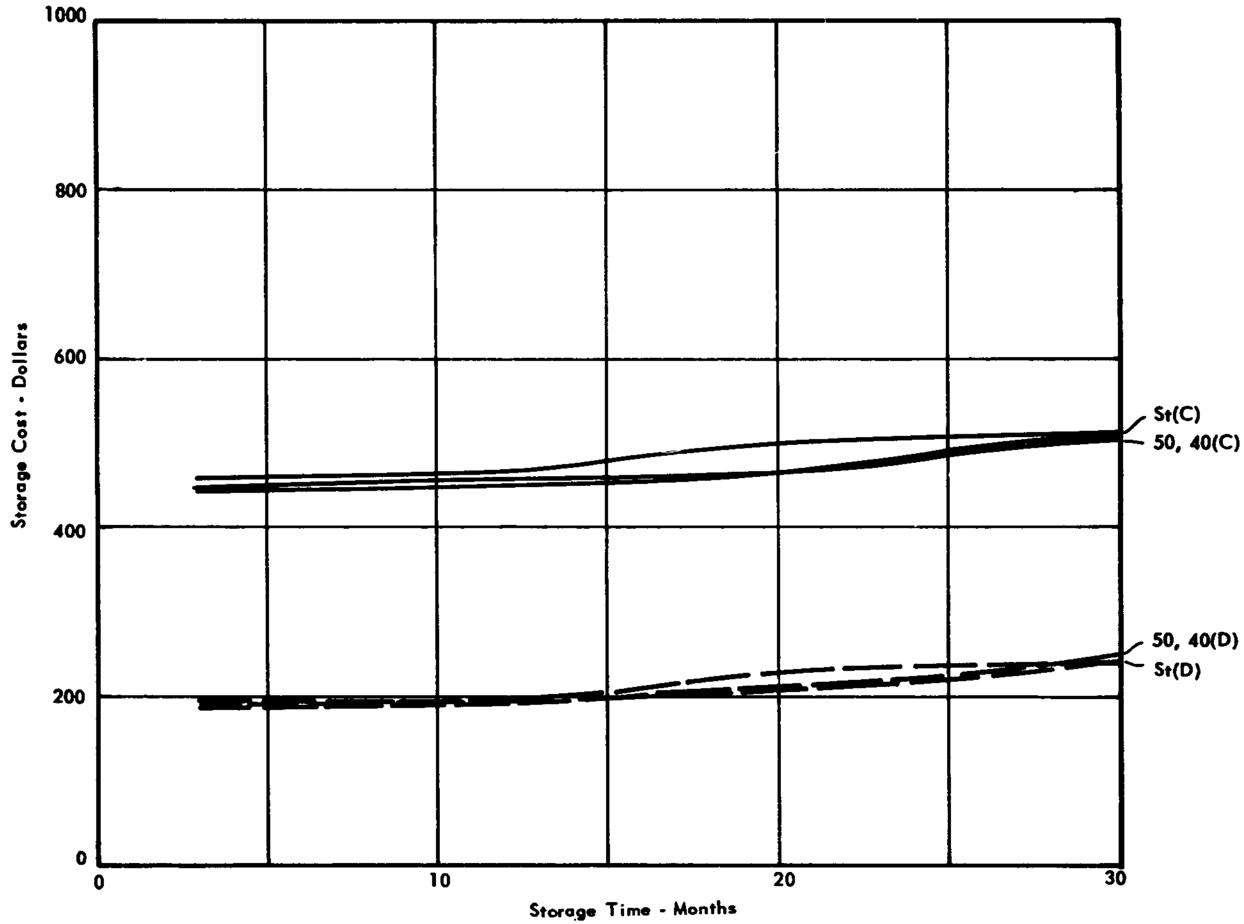


Figure C-6. Storage Cost Versus Storage Time for Group VI Items.

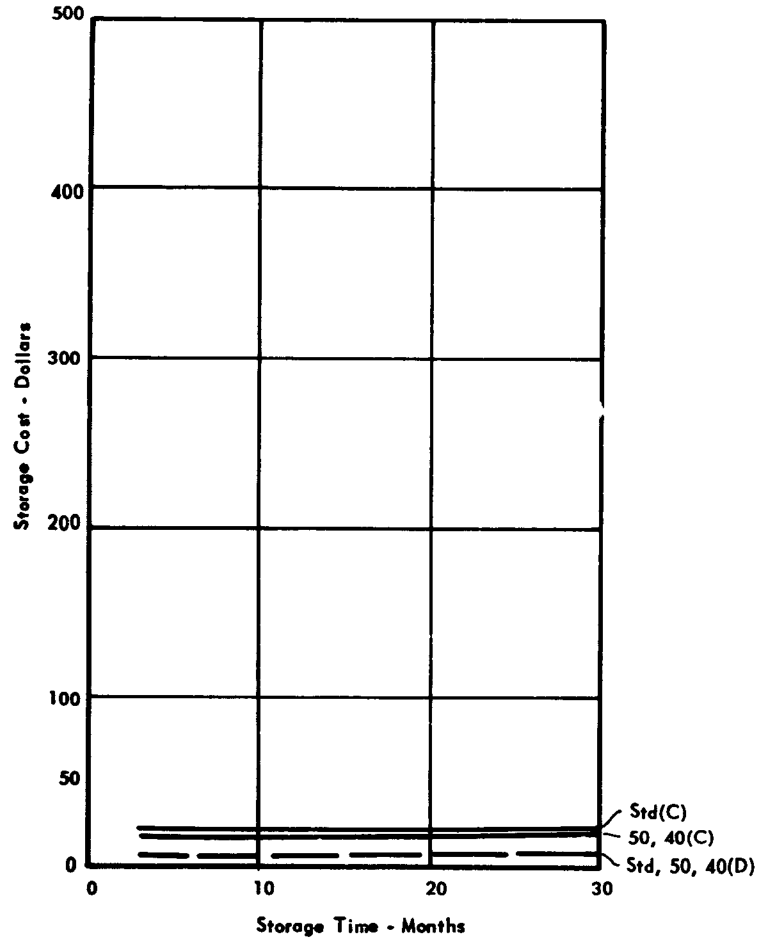


Figure C-6a. Meat Slicer.

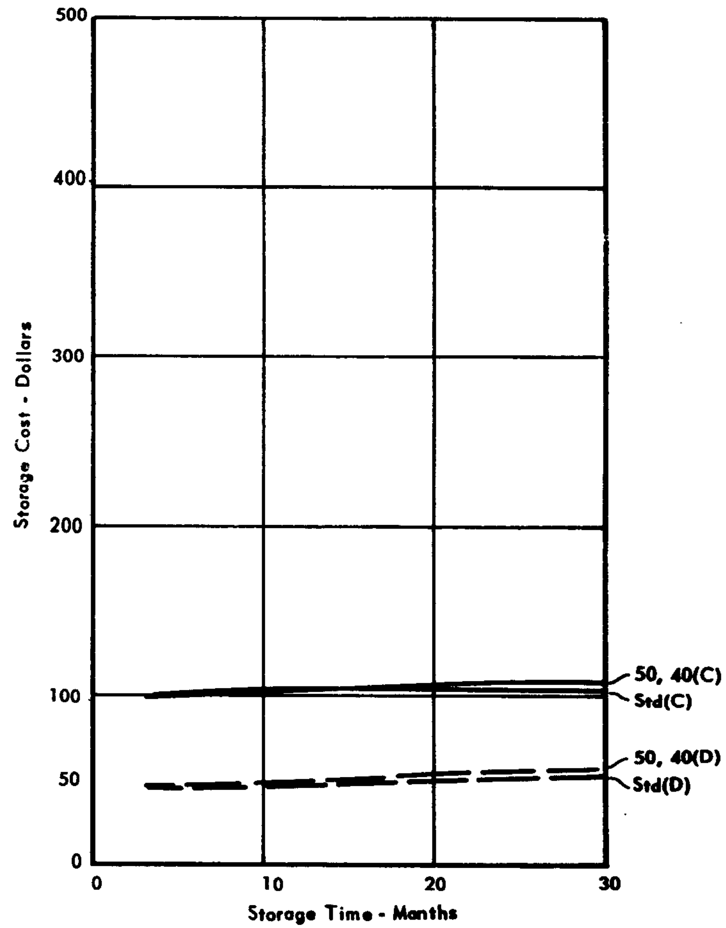


Figure C-6b. Public Address System.

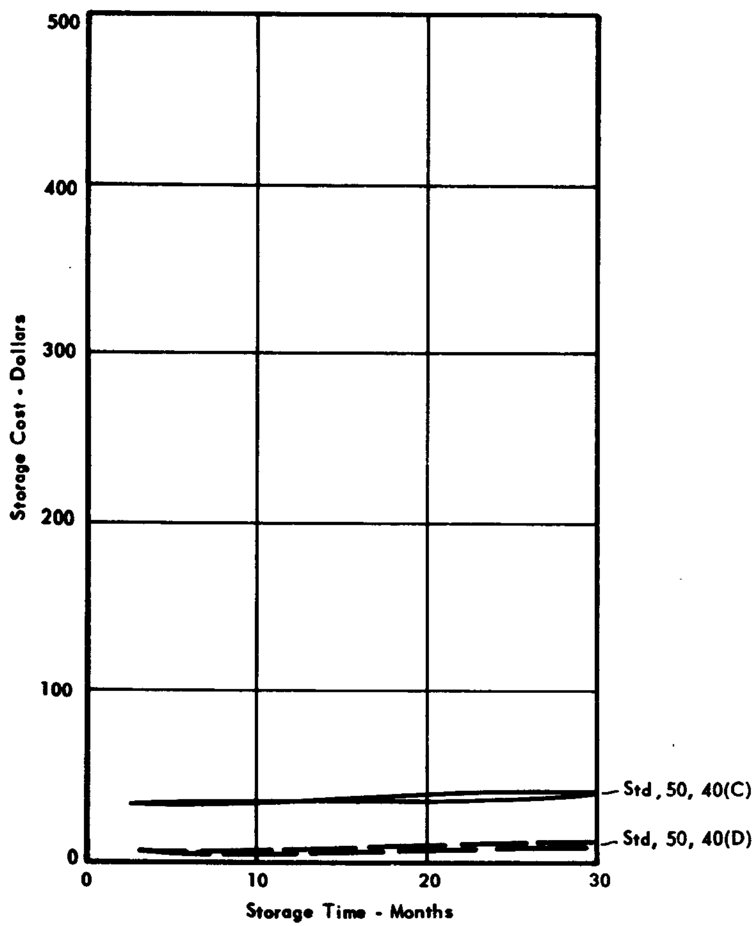


Figure C-6c. Telephone System 13 Unit.

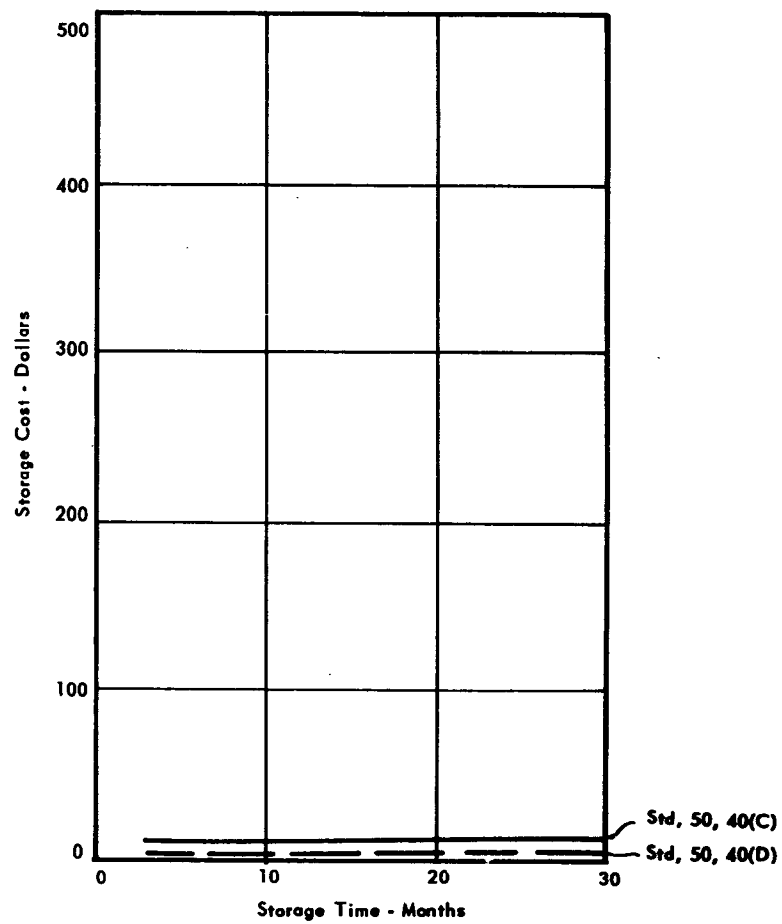


Figure C-6d. Transit, Surveyers.

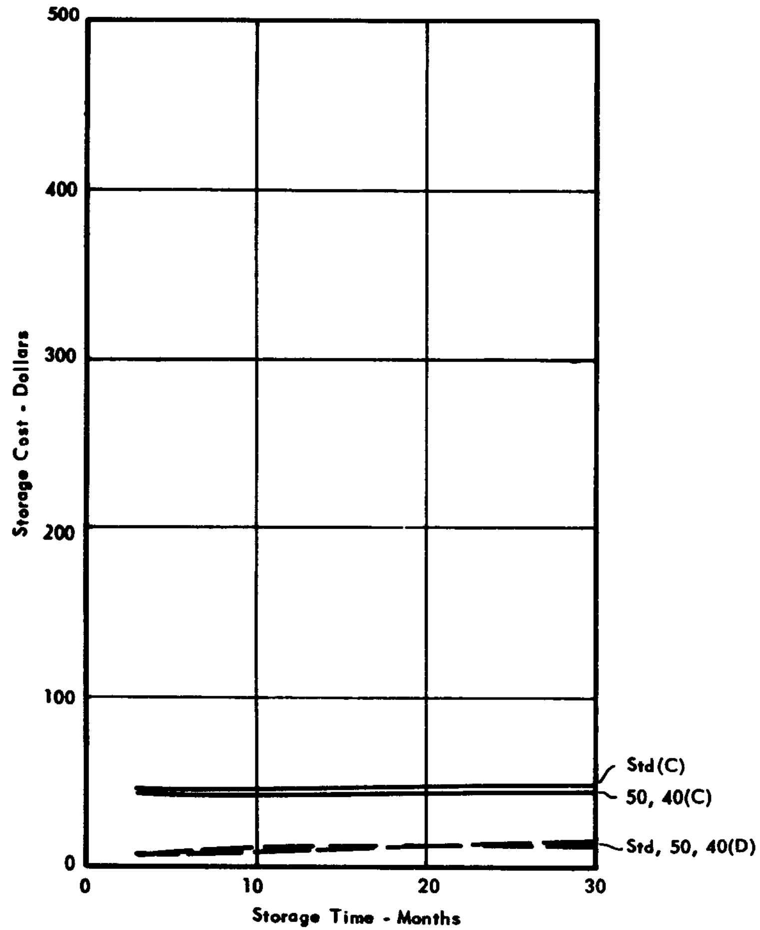


Figure C-6e. Drill Press 18 Inch.

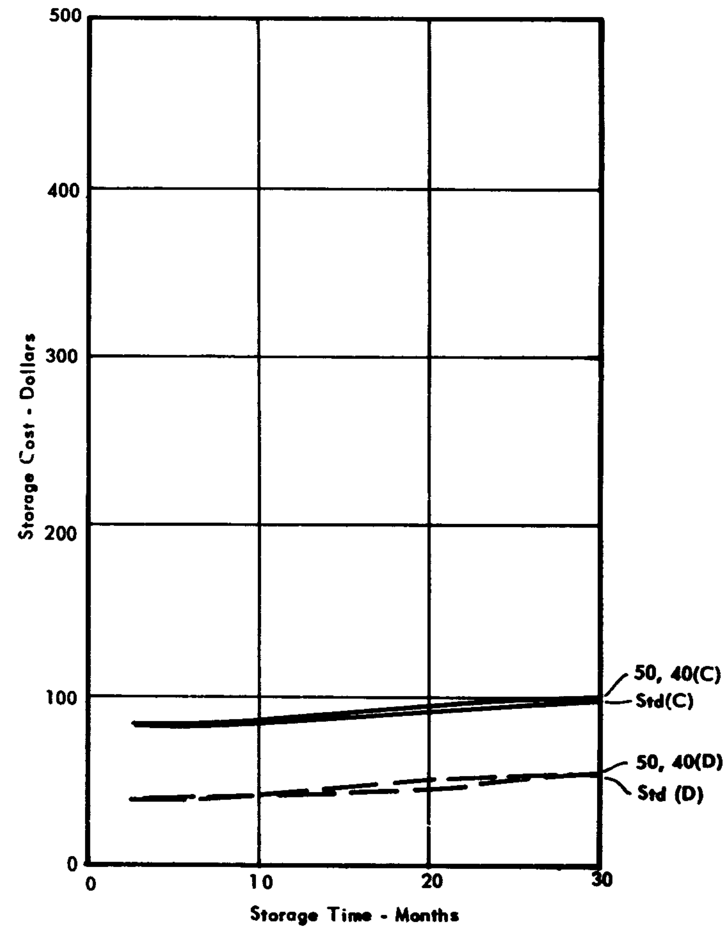


Figure C-6f. Lathe Floor Model.

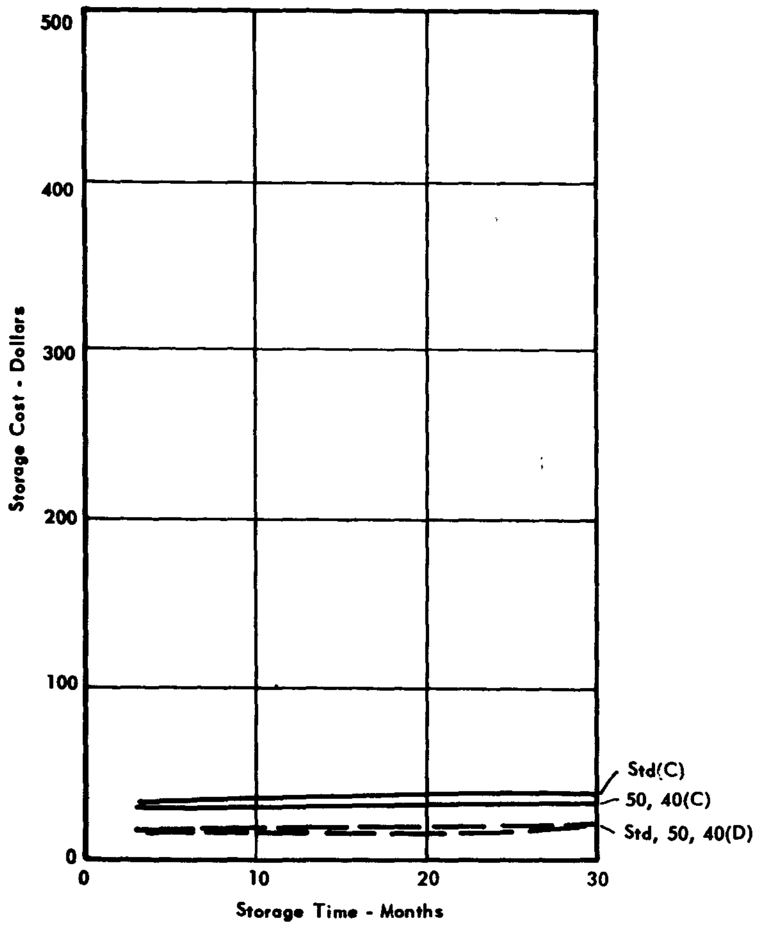


Figure C-6g. Fan Exhaust 4900 CFM.

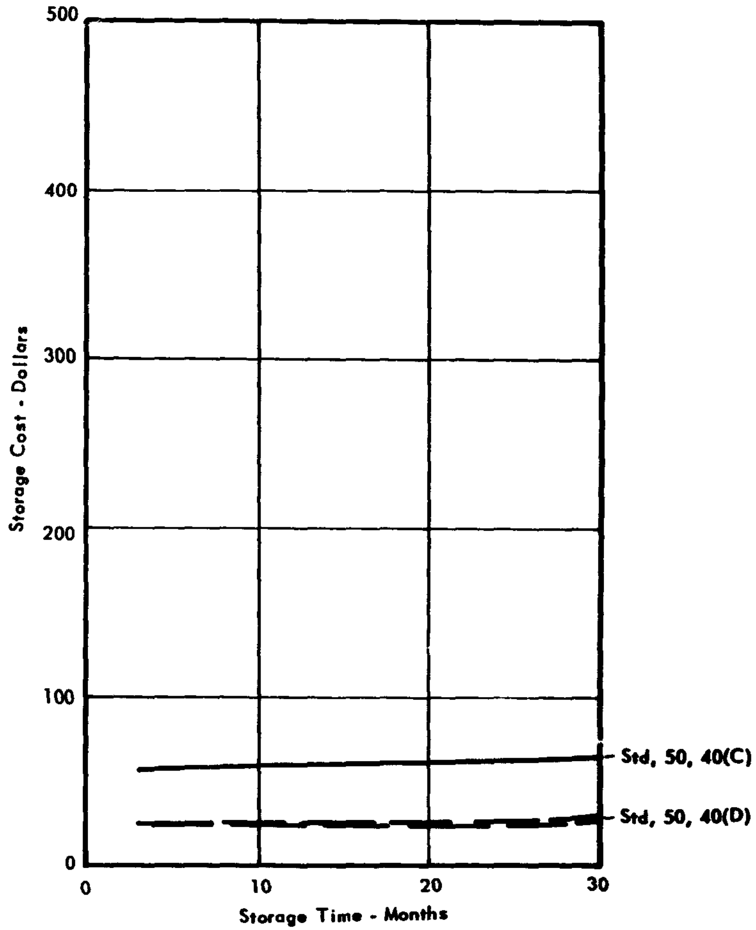


Figure C-6h. Switch Board 50 Line.

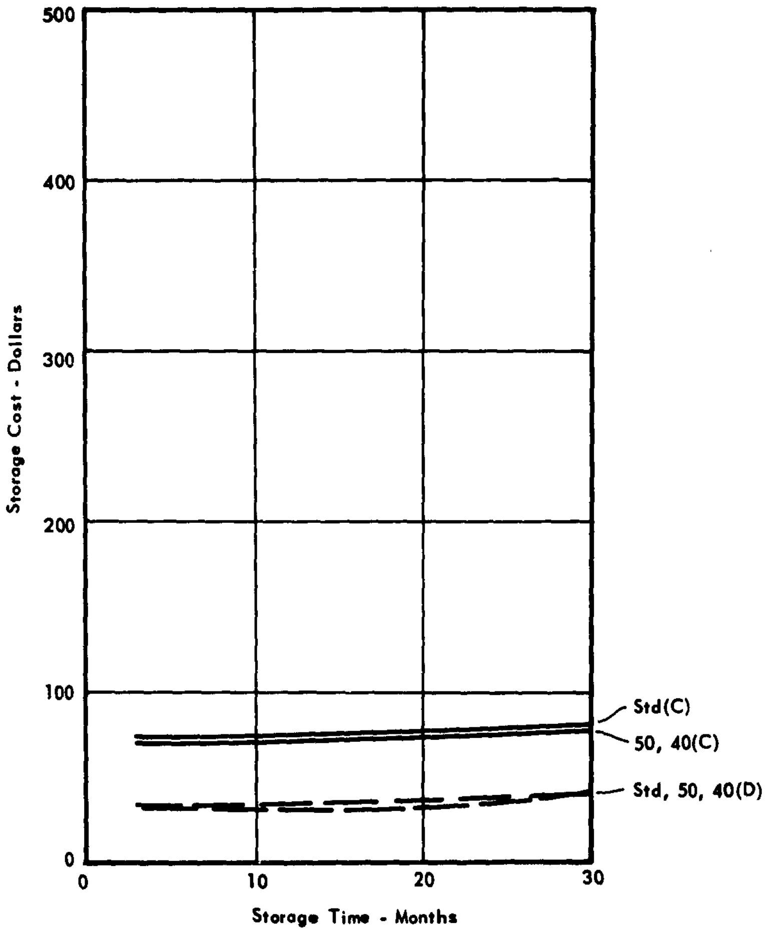
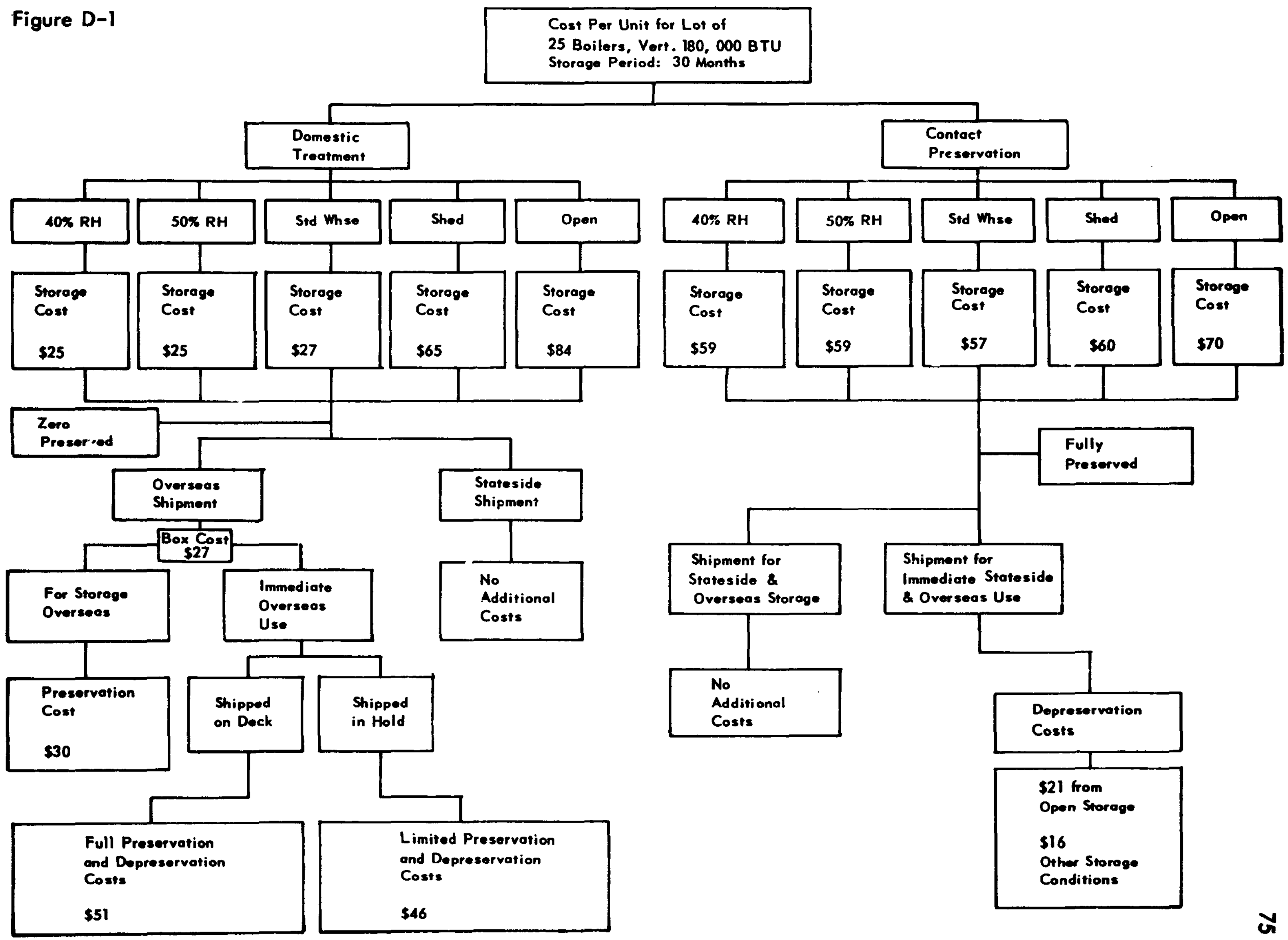


Figure C-6i. Saw Radical 16 Inch.

Figure D-1



Cost Per Unit for Lot of
25 Boilers, Vert. 180, 000 BTU
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $25
Storage Cost $25
Storage Cost $27
Storage Cost $65
Storage Cost $84
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $59
Storage Cost $59
Storage Cost $57
Storage Cost $60
Storage Cost $70
Zero Preser-ed
Overseas Shipment
Stateside Shipment
Box Cost $27
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $30
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $51
Limited Preservation and Depreservation Costs $46
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$21 from Open Storage
$16 Other Storage Conditions

Figure D-2

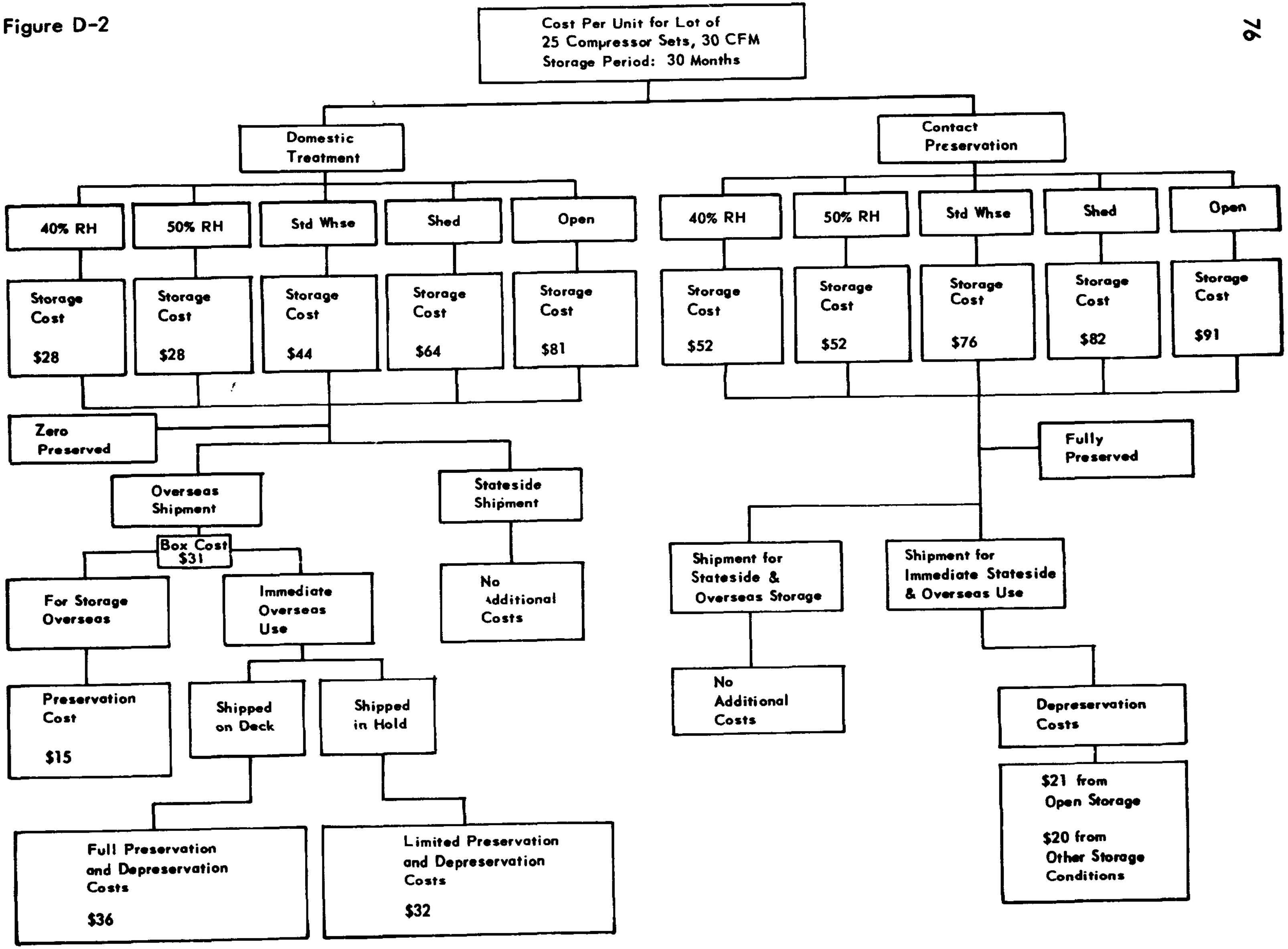
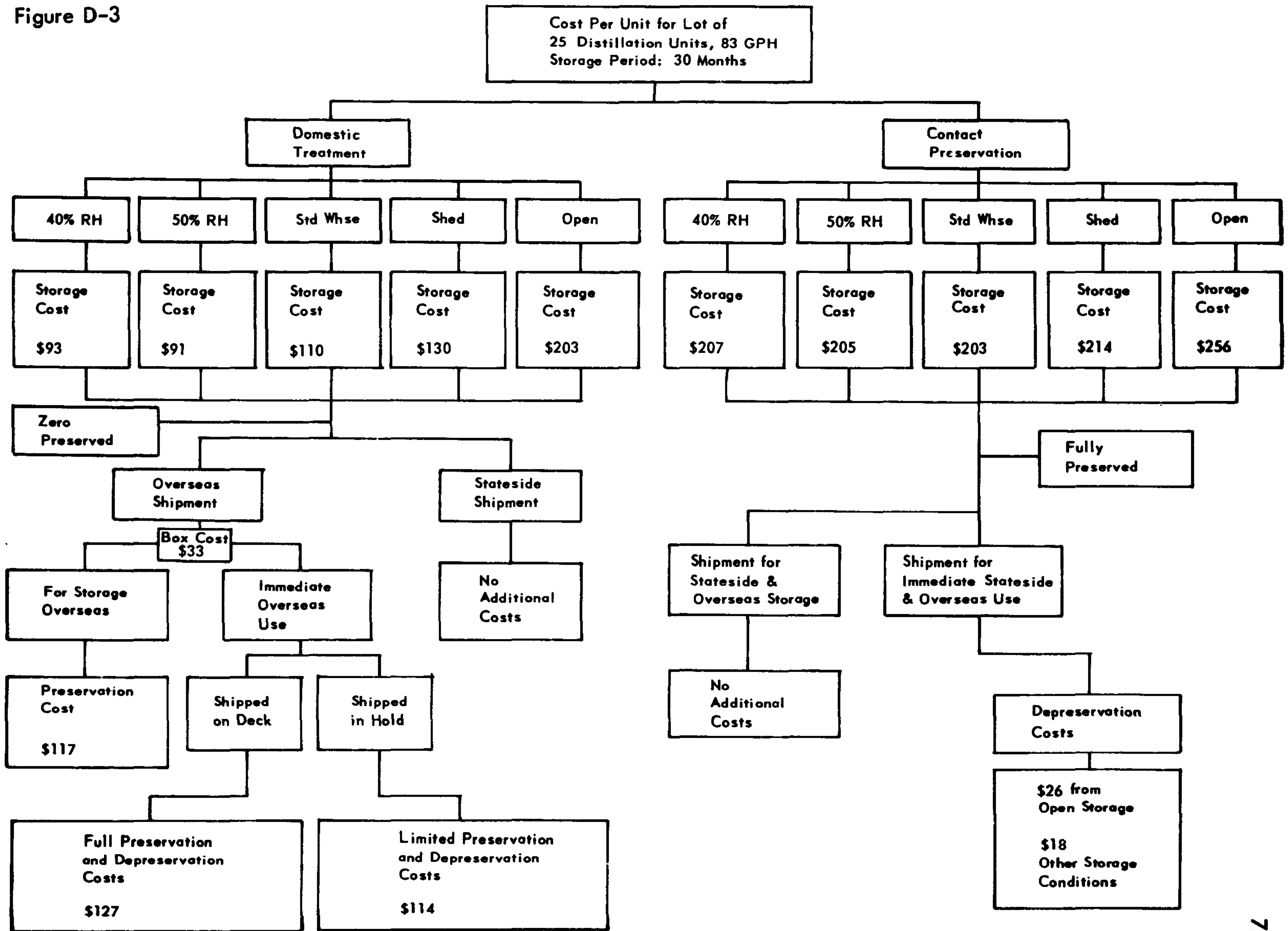

Cost Per Unit for Lot of
25 Compressor Sets, 30 CFM
Storage Period: 30 Months
Domestic Treatment
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $28
Storage Cost $28
Storage Cost $44
Storage Cost $64
Storage Cost $81
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $31
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $15
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $36
Limited Preservation and Depreservation Costs $32
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $52
Storage Cost $52
Storage Cost $76
Storage Cost $82
Storage Cost $91
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$21 from Open Storage
$20 from Other Storage Conditions

Figure D-3



Cost Per Unit for Lot of
25 Distillation Units, 83 GPH
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $93
Storage Cost $91
Storage Cost $110
Storage Cost $130
Storage Cost $203
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $207
Storage Cost $205
Storage Cost $203
Storage Cost $214
Storage Cost $256
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $33
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $117
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $127
Limited Preservation and Depreservation Costs $114
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$26 from Open Storage
$18 Other Storage Conditions

Figure D-4

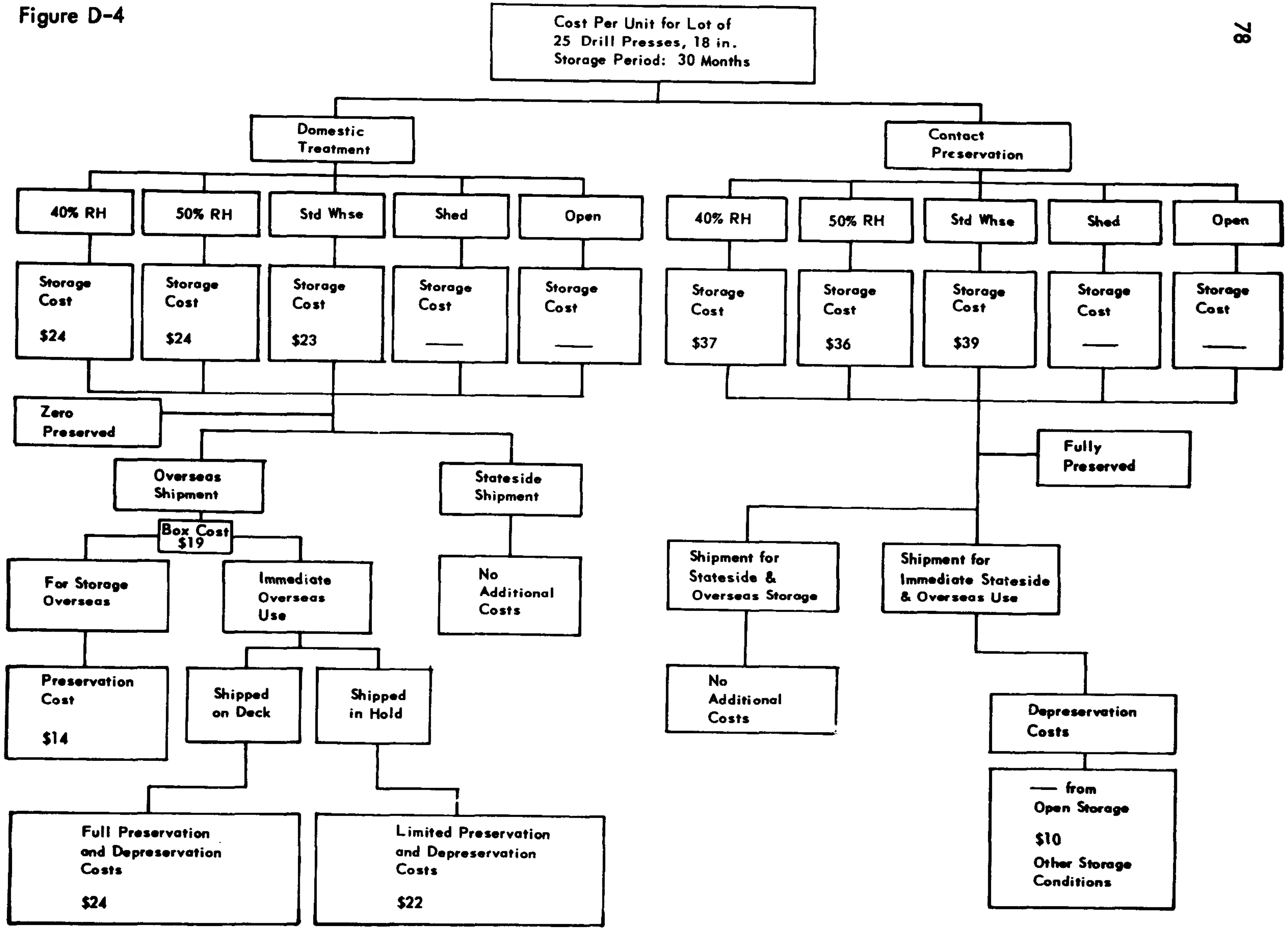
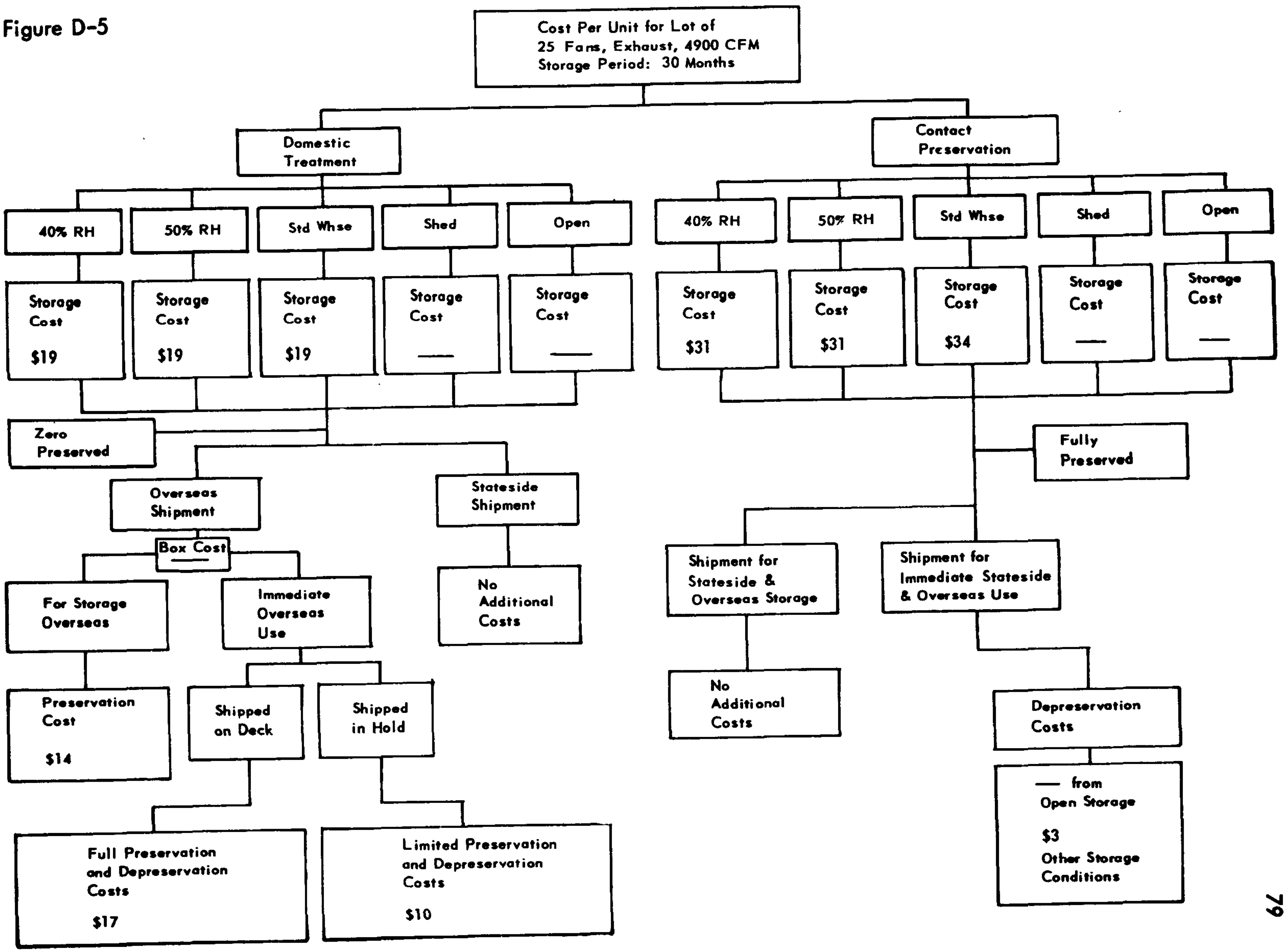

Cost Per Unit for Lot of 25 Drill Presses, 18 in. Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $24
Storage Cost $24
Storage Cost $23
Storage Cost —
Storage Cost —
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $37
Storage Cost $36
Storage Cost $39
Storage Cost —
Storage Cost —
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $19
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $14
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $24
Limited Preservation and Depreservation Costs $22
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
— from Open Storage
$10
Other Storage Conditions

Figure D-5



Cost Per Unit for Lot of
25 Fans, Exhaust, 4900 CFM
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $19
Storage Cost $19
Storage Cost $19
Storage Cost —
Storage Cost —
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $31
Storage Cost $31
Storage Cost $34
Storage Cost —
Storage Cost —
Zero Preserved
Overseas Shipment
Box Cost —
Stateside Shipment
No Additional Costs
For Storage Overseas
Immediate Overseas Use
Preservation Cost $14
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $17
Limited Preservation and Depreservation Costs $10
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
— from Open Storage
$3 Other Storage Conditions

Figure D-6

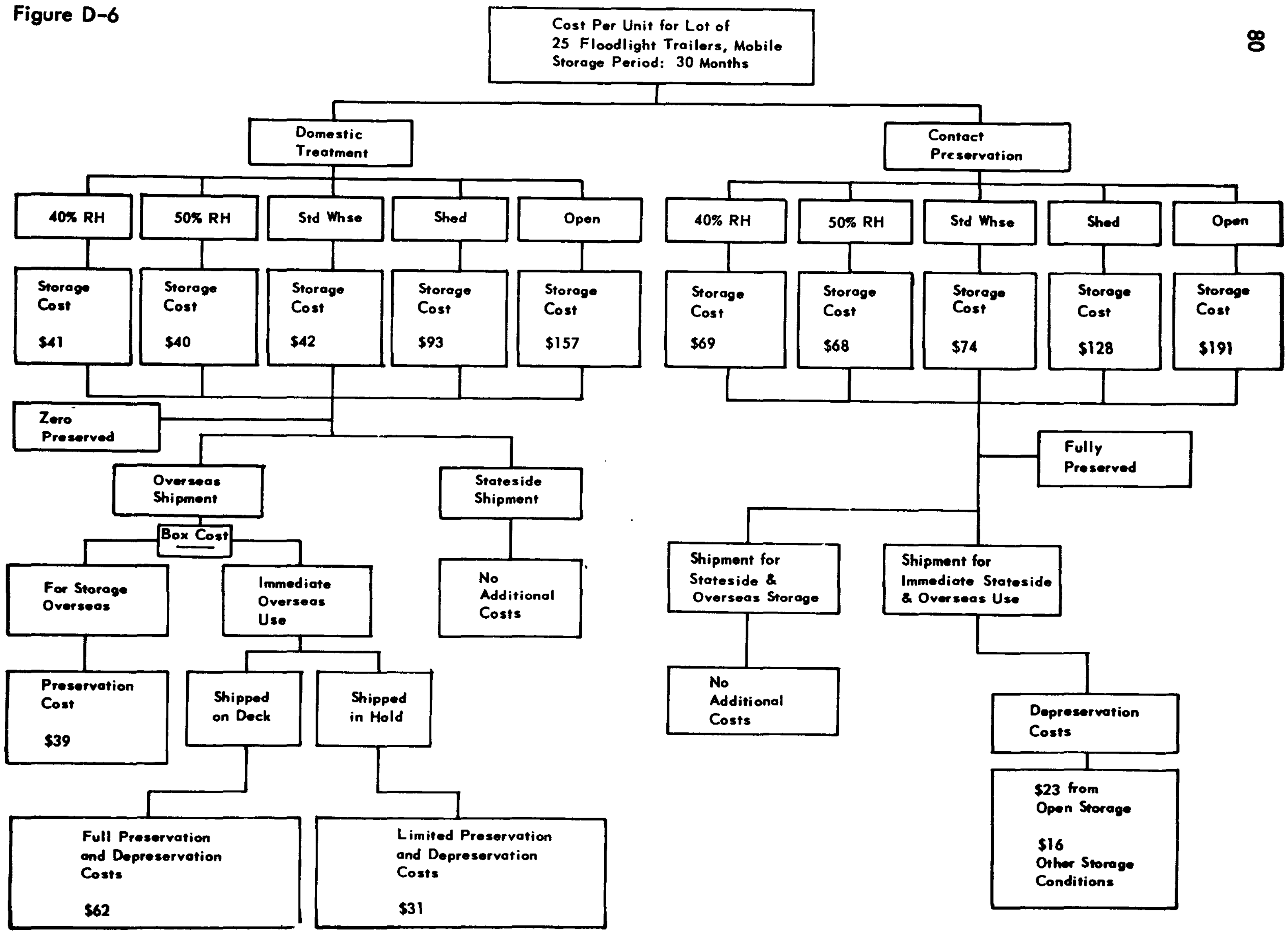

Cost Per Unit for Lot of
25 Floodlight Trailers, Mobile
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $41
Storage Cost $40
Storage Cost $42
Storage Cost $93
Storage Cost $157
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $69
Storage Cost $68
Storage Cost $74
Storage Cost $128
Storage Cost $191
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $39
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $62
Limited Preservation and Depreservation Costs $31
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$23 from Open Storage
$16 Other Storage Conditions

Figure D-7

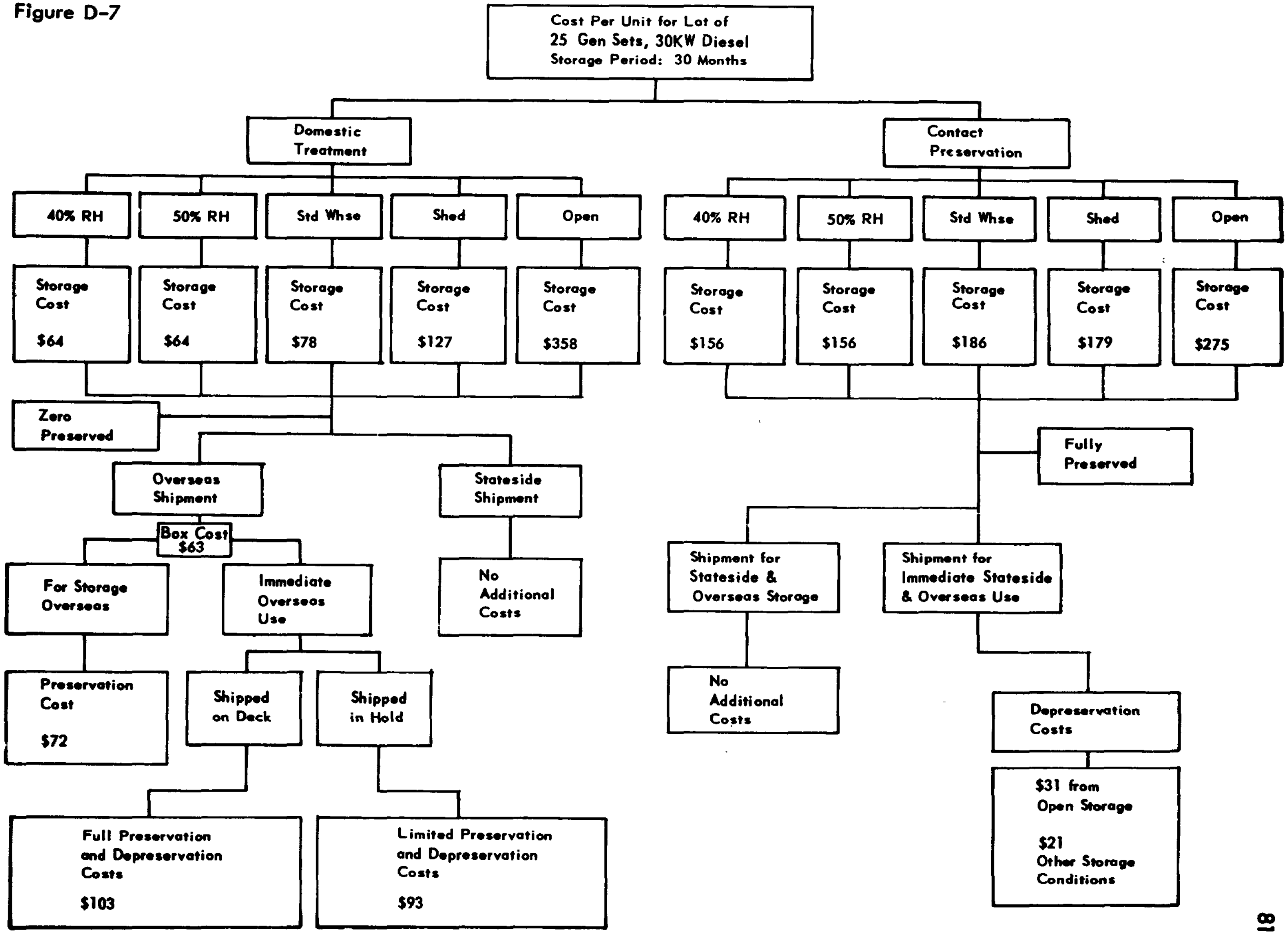
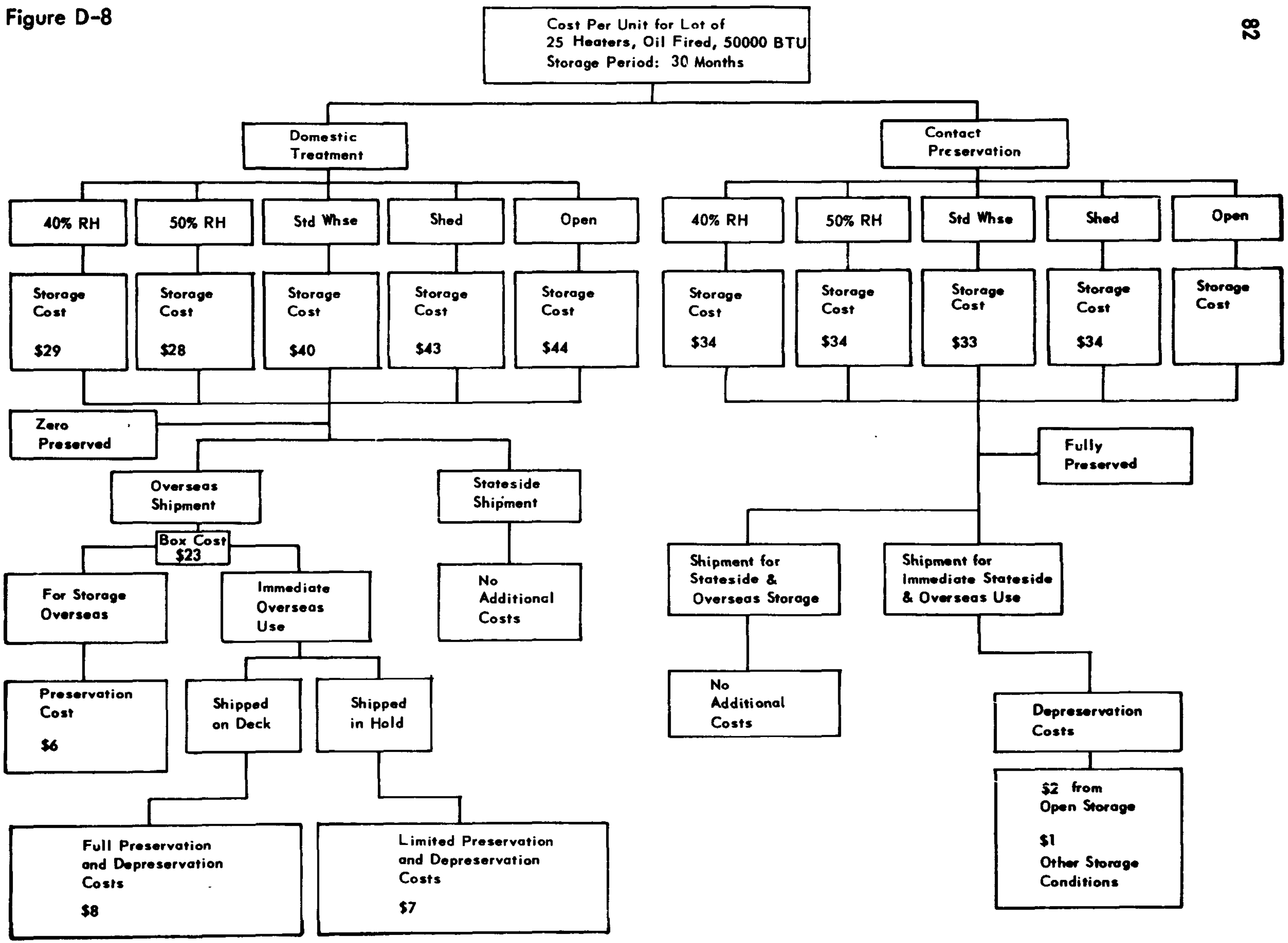
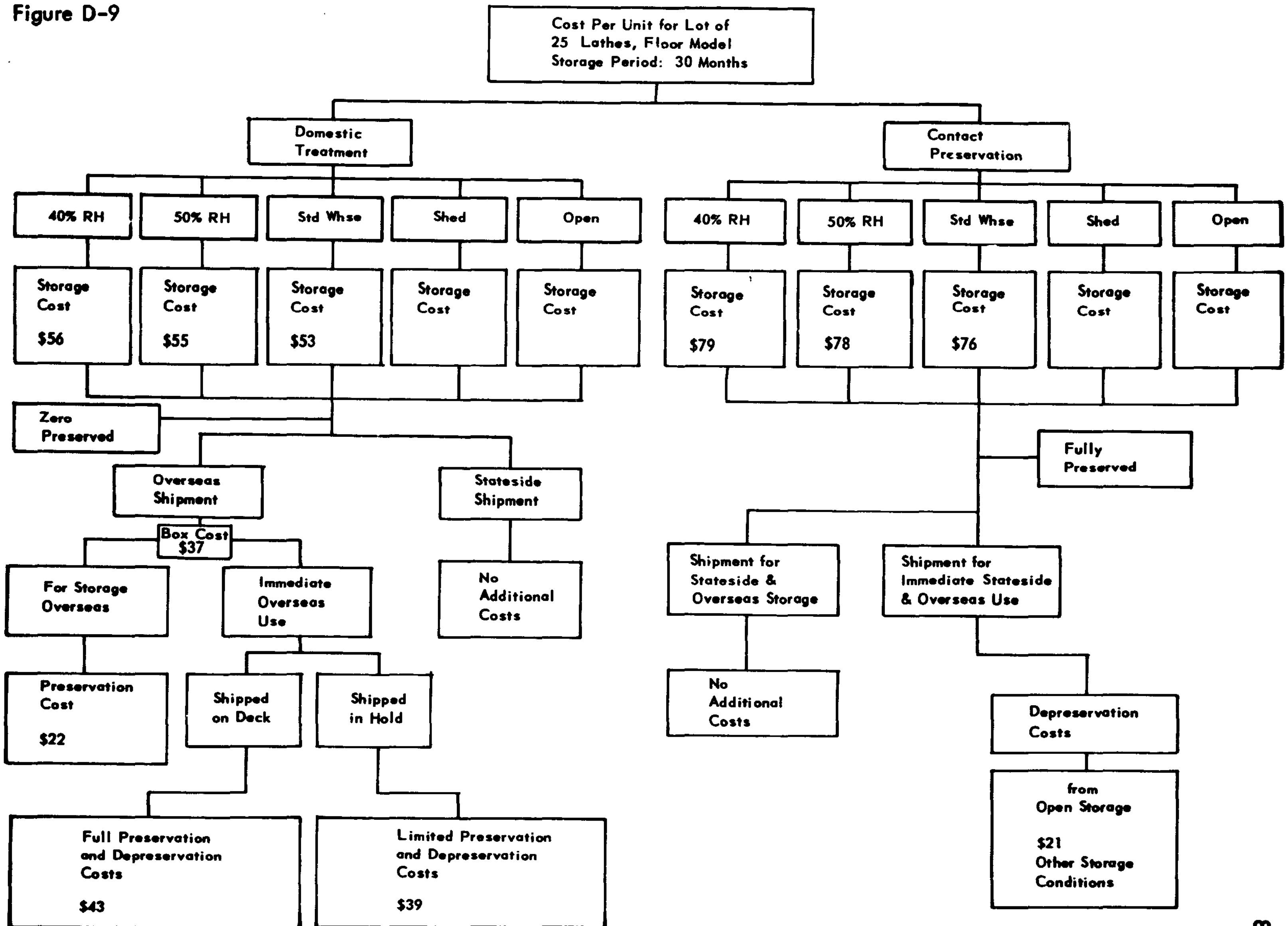

Cost Per Unit for Lot of
25 Gen Sets, 30KW Diesel
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $64
Storage Cost $64
Storage Cost $78
Storage Cost $127
Storage Cost $358
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $156
Storage Cost $156
Storage Cost $186
Storage Cost $179
Storage Cost $275
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $63
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $72
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $103
Limited Preservation and Depreservation Costs $93
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$31 from Open Storage
$21 Other Storage Conditions

Figure D-8



Cost Per Unit for Lot of
25 Heaters, Oil Fired, 50000 BTU
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $29
Storage Cost $28
Storage Cost $40
Storage Cost $43
Storage Cost $44
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $34
Storage Cost $34
Storage Cost $33
Storage Cost $34
Storage Cost
Zero Preserved
Overseas Shipment
Box Cost $23
Stateside Shipment
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $6
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $8
Limited Preservation and Depreservation Costs $7
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$2 from Open Storage
$1 Other Storage Conditions

Figure D-9



Cost Per Unit for Lot of
25 Lathes, Floor Model
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $56
Storage Cost $55
Storage Cost $53
Storage Cost
Storage Cost
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $79
Storage Cost $78
Storage Cost $76
Storage Cost
Storage Cost
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $37
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $22
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $43
Limited Preservation and Depreservation Costs $39
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
from Open Storage
$21
Other Storage Conditions

Figure D-10

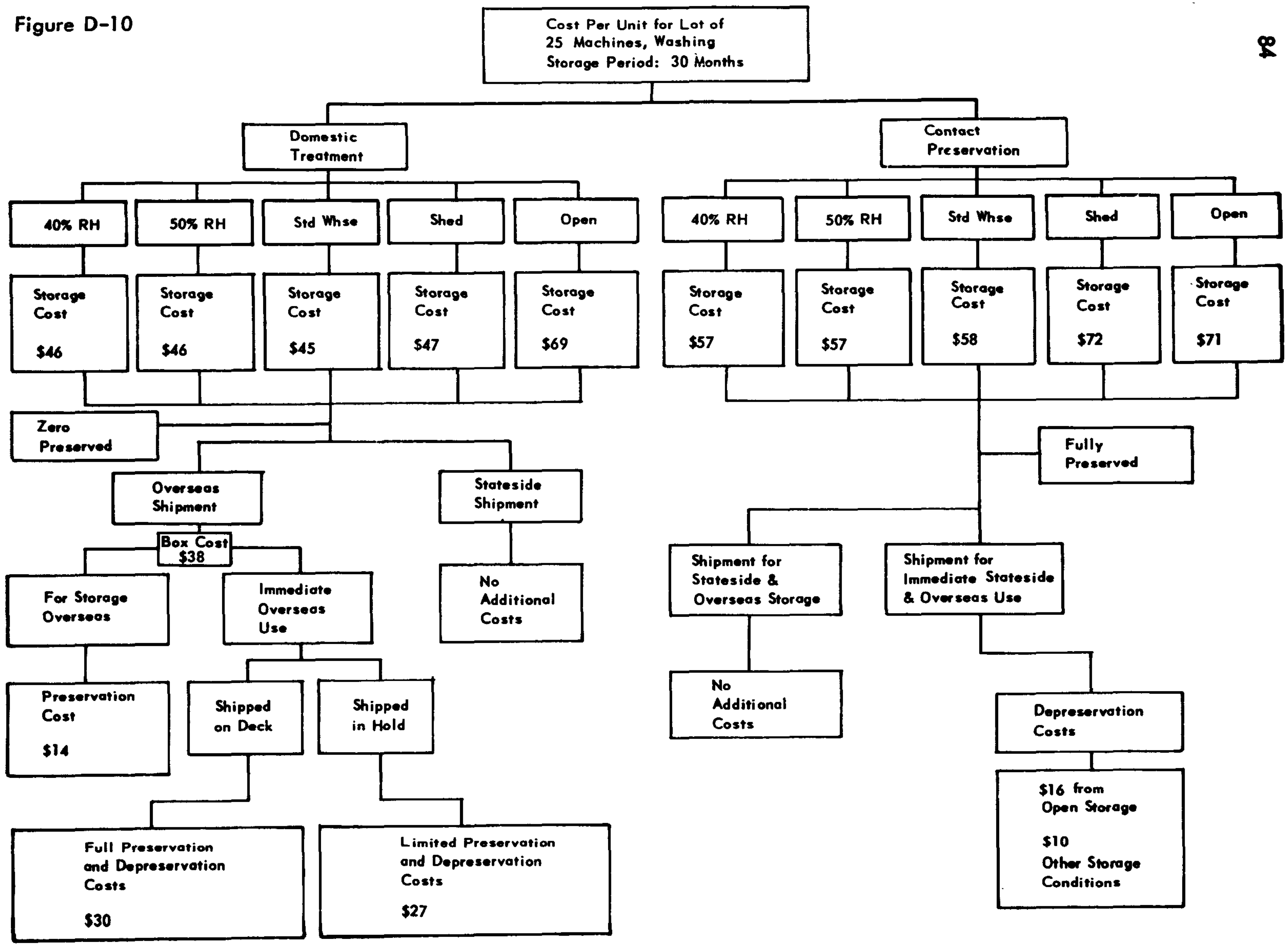
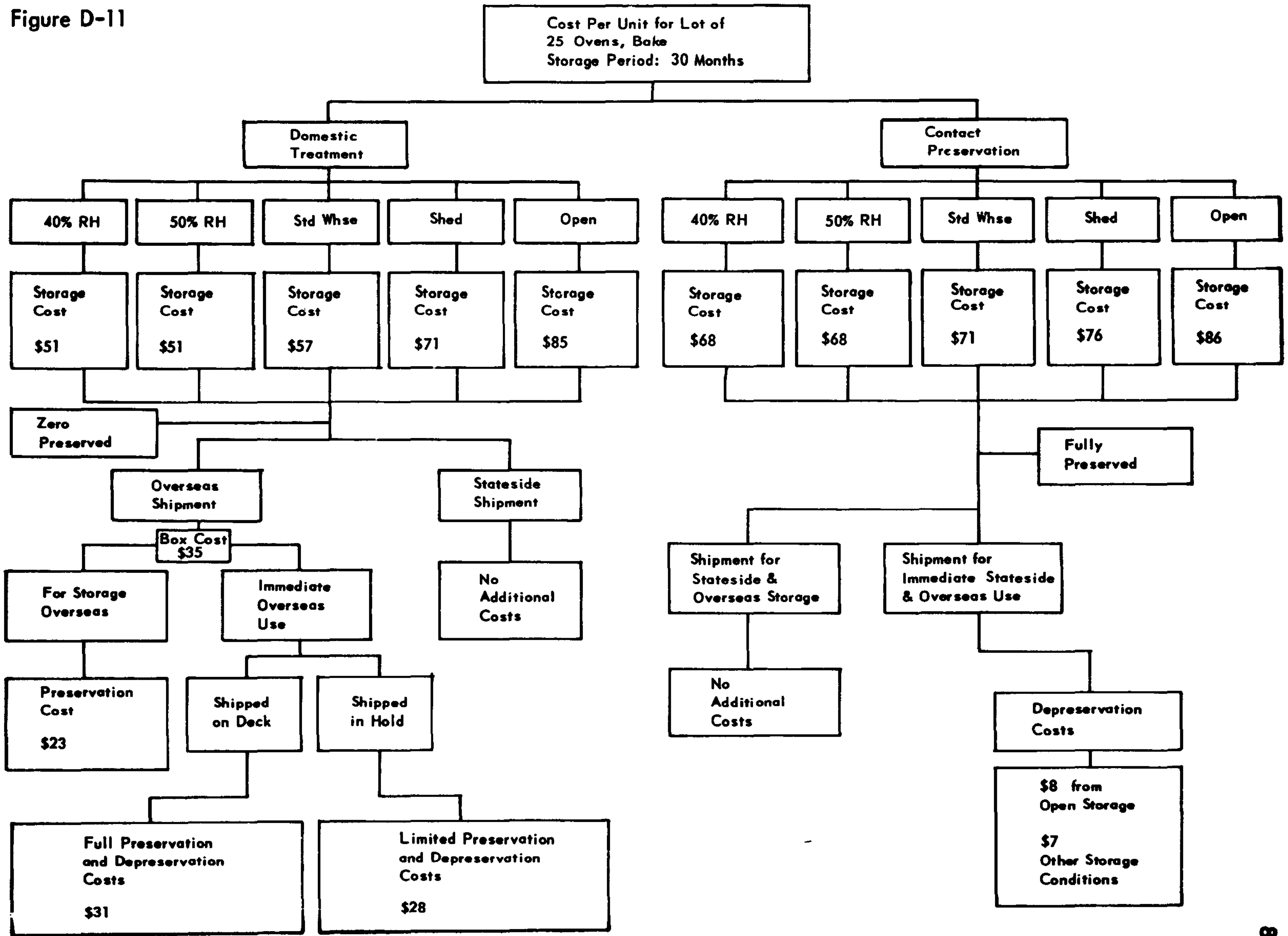

Cost Per Unit for Lot of
25 Machines, Washing
Storage Period: 30 Months
Domestic Treatment
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $46
Storage Cost $46
Storage Cost $45
Storage Cost $47
Storage Cost $69
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $38
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $14
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $30
Limited Preservation and Depreservation Costs $27
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $57
Storage Cost $57
Storage Cost $58
Storage Cost $72
Storage Cost $71
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$16 from Open Storage
$10 Other Storage Conditions

Figure D-11



Cost Per Unit for Lot of 25 Ovens, Bake Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $51
Storage Cost $51
Storage Cost $57
Storage Cost $71
Storage Cost $85
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $68
Storage Cost $68
Storage Cost $71
Storage Cost $76
Storage Cost $86
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $35
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $23
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $31
Limited Preservation and Depreservation Costs $28
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$8 from Open Storage
$7 Other Storage Conditions

Figure D-12

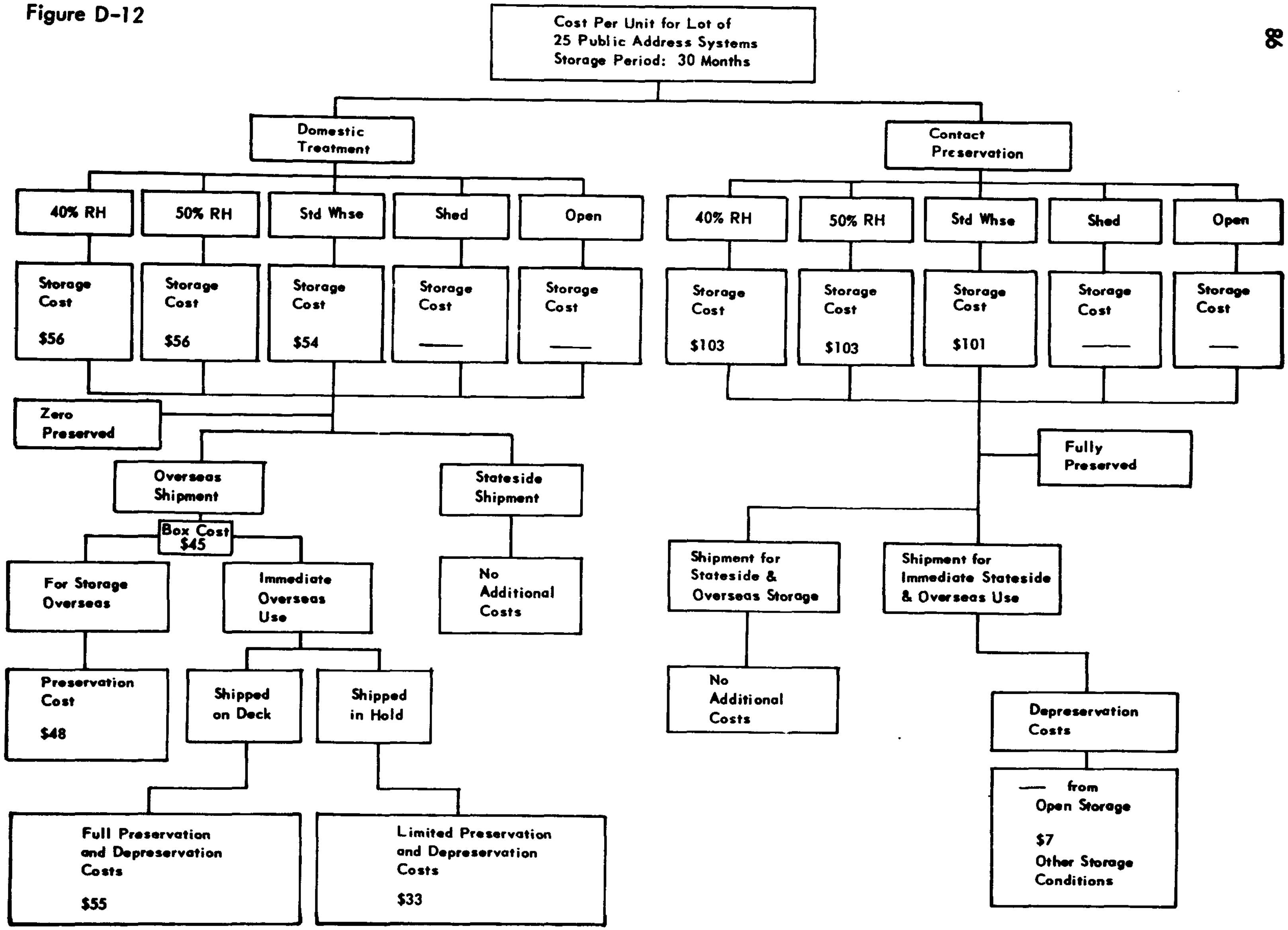
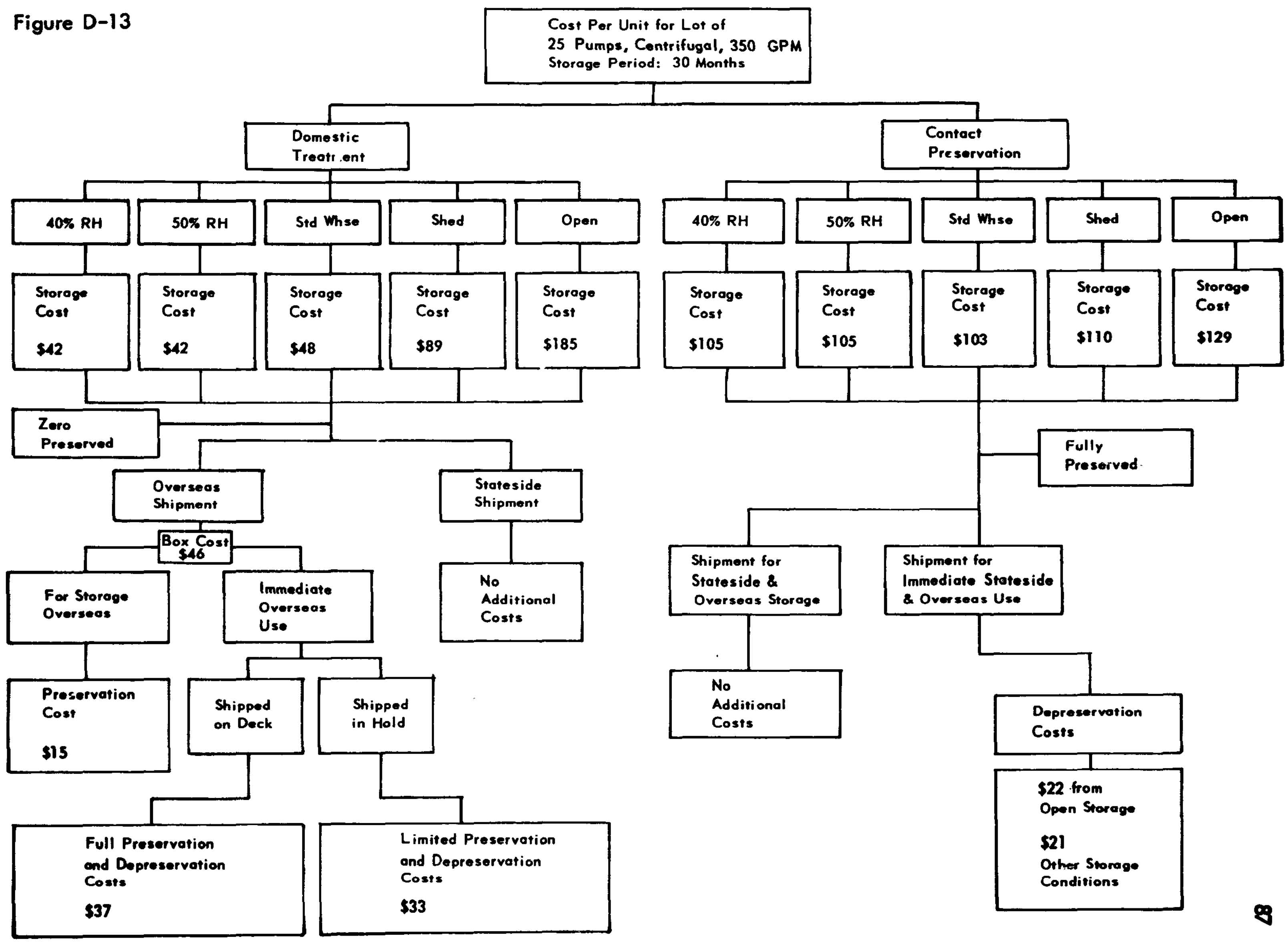

Cost Per Unit for Lot of
25 Public Address Systems
Storage Period: 30 Months
Domestic Treatment
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $56
Storage Cost $56
Storage Cost $54
Storage Cost —
Storage Cost —
Zero Preserved
Overseas Shipment
Box Cost $45
Stateside Shipment
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $48
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $55
Limited Preservation and Depreservation Costs $33
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $103
Storage Cost $103
Storage Cost $101
Storage Cost —
Storage Cost —
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
— from Open Storage
$7 Other Storage Conditions

Figure D-13



Cost Per Unit for Lot of
25 Pumps, Centrifugal, 350 GPM
Storage Period: 30 Months
Domestic Treatr.ent
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $42
Storage Cost $42
Storage Cost $48
Storage Cost $89
Storage Cost $185
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $105
Storage Cost $105
Storage Cost $103
Storage Cost $110
Storage Cost $129
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $46
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $15
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $37
Limited Preservation and Depreservation Costs $33
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$22 from Open Storage
$21 Other Storage Conditions

Figure D-14

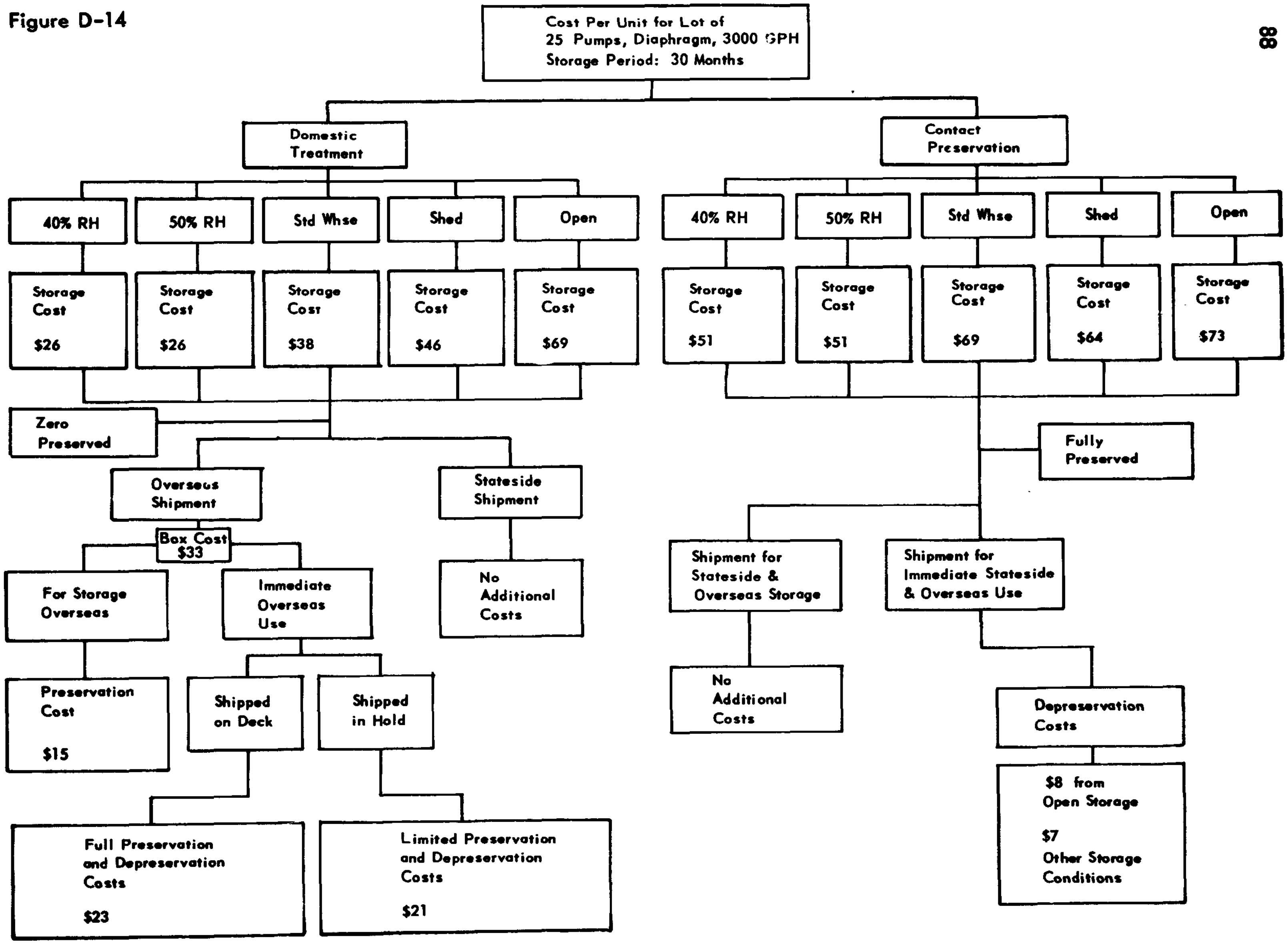
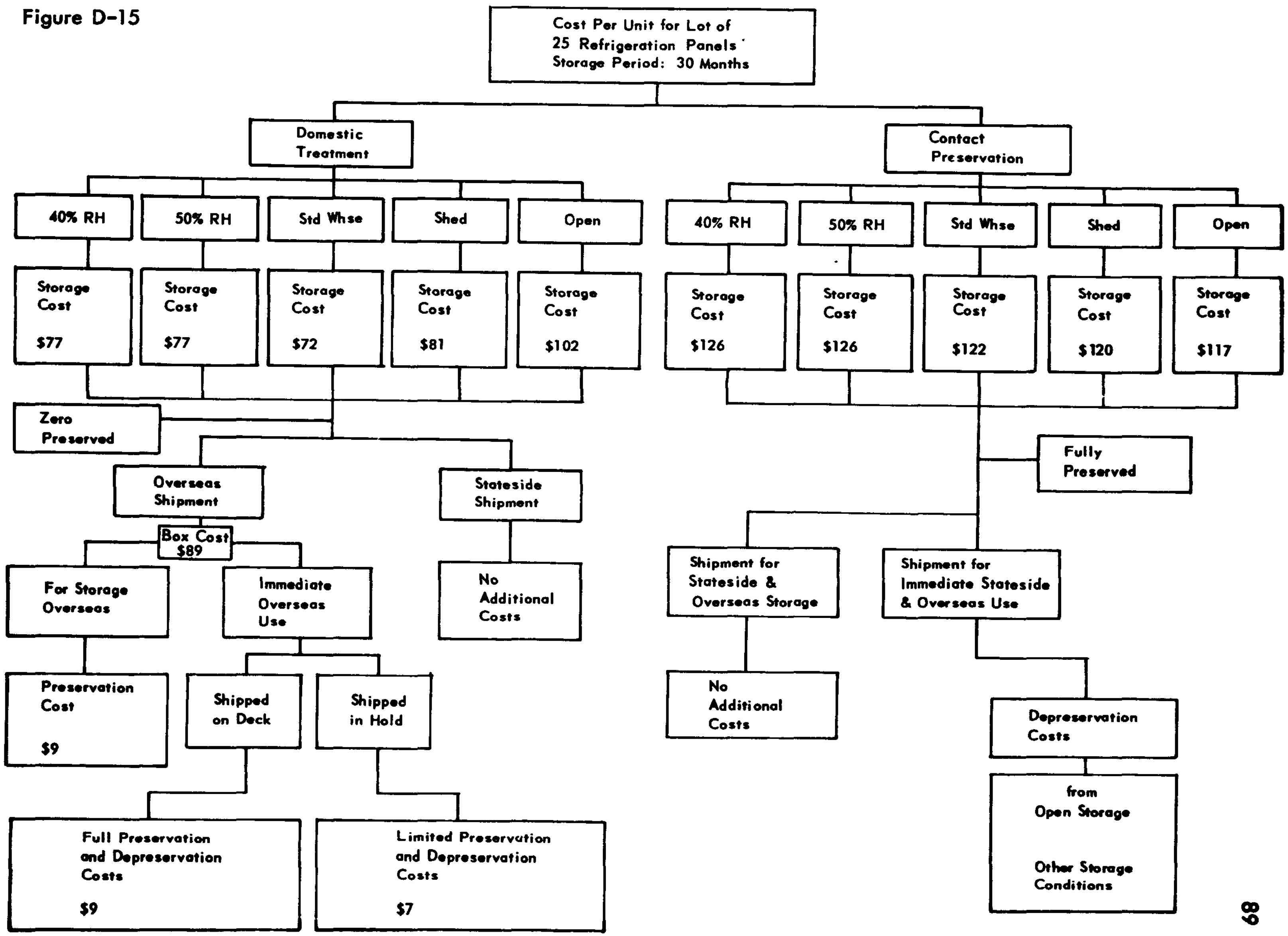
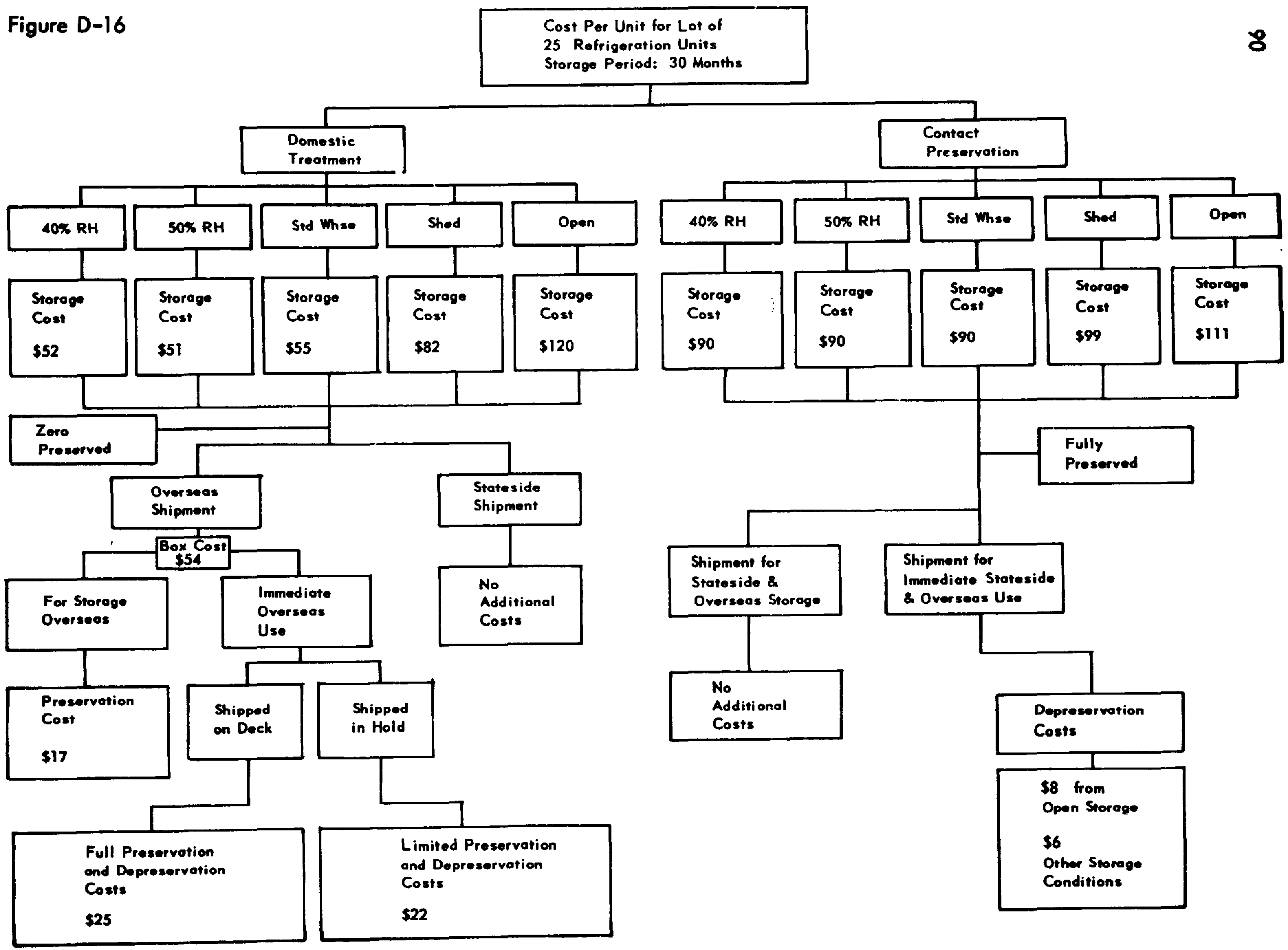

Cost Per Unit for Lot of
25 Pumps, Diaphragm, 3000 GPH
Storage Period: 30 Months
Domestic Treatment
40% RH
Storage Cost $26
50% RH
Storage Cost $26
Std Whse
Storage Cost $38
Shed
Storage Cost $46
Open
Storage Cost $69
Zero Preserved
Overseas Shipment
Box Cost $33
For Storage Overseas
Preservation Cost $15
Immediate Overseas Use
Shipped on Deck
Full Preservation and Depreservation Costs $23
Shipped in Hold
Limited Preservation and Depreservation Costs $21
Stateside Shipment
No Additional Costs
Contact Preservation
40% RH
Storage Cost $51
50% RH
Storage Cost $51
Std Whse
Storage Cost $69
Shed
Storage Cost $64
Open
Storage Cost $73
Fully Preserved
Shipment for Stateside & Overseas Storage
No Additional Costs
Shipment for Immediate Stateside & Overseas Use
Depreservation Costs
$8 from Open Storage
$7 Other Storage Conditions

Figure D-15



Cost Per Unit for Lot of 25 Refrigeration Panels Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $77
Storage Cost $77
Storage Cost $72
Storage Cost $81
Storage Cost $102
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $126
Storage Cost $126
Storage Cost $122
Storage Cost $120
Storage Cost $117
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $89
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $9
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $9
Limited Preservation and Depreservation Costs $7
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
from Open Storage
Other Storage Conditions

Figure D-16



Cost Per Unit for Lot of
25 Refrigeration Units
Storage Period: 30 Months
Domestic Treatment
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $52
Storage Cost $51
Storage Cost $55
Storage Cost $82
Storage Cost $120
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $54
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $17
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $25
Limited Preservation and Depreservation Costs $22
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $90
Storage Cost $90
Storage Cost $90
Storage Cost $99
Storage Cost $111
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$8 from Open Storage
$6 Other Storage Conditions

Figure D-17

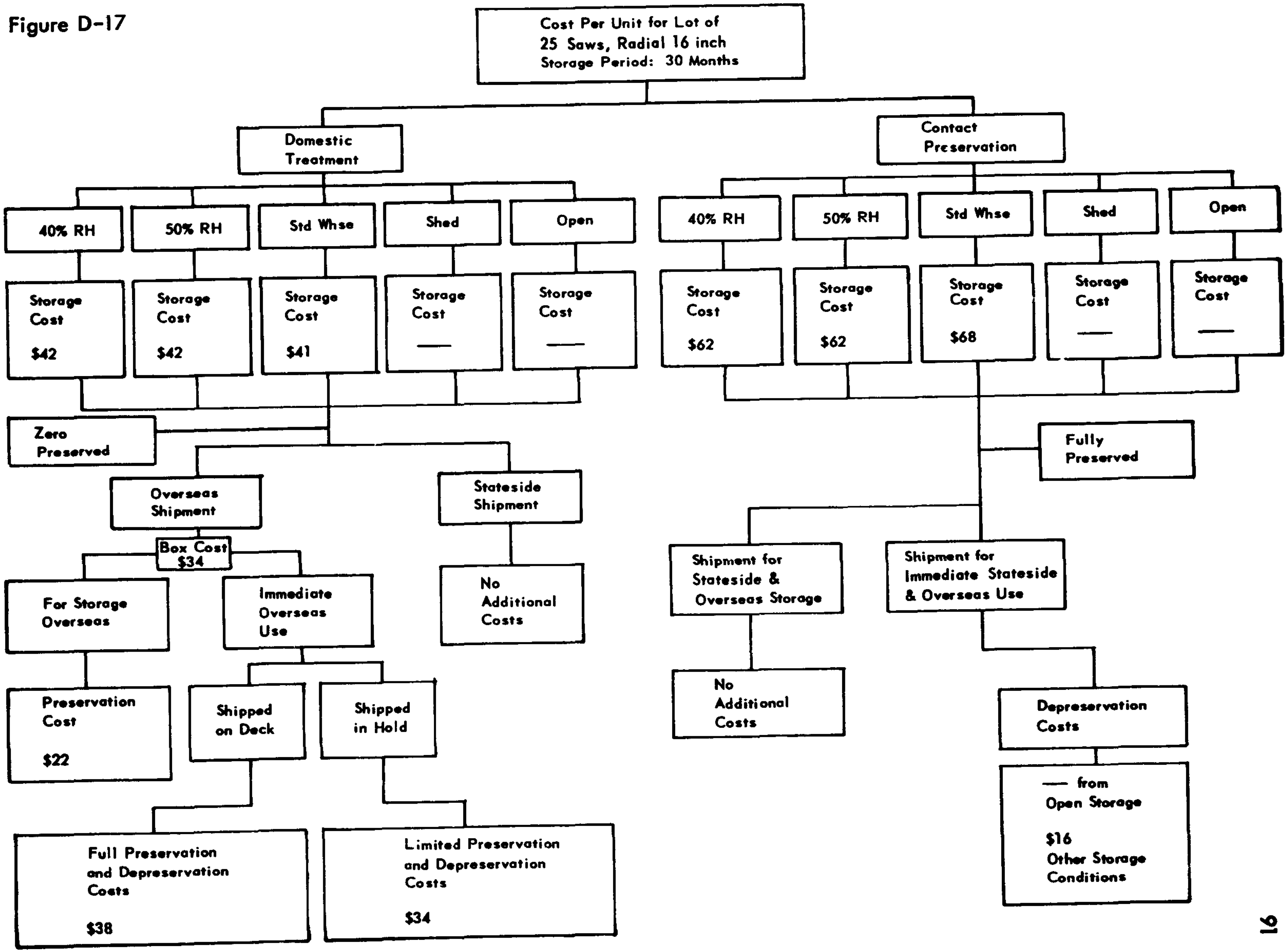

Cost Per Unit for Lot of 25 Saws, Radial 16 inch Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $42
Storage Cost $42
Storage Cost $41
Storage Cost —
Storage Cost —
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $62
Storage Cost $62
Storage Cost $68
Storage Cost —
Storage Cost —
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $34
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $22
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $38
Limited Preservation and Depreservation Costs $34
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
— from Open Storage
$16 Other Storage Conditions

Figure D-18

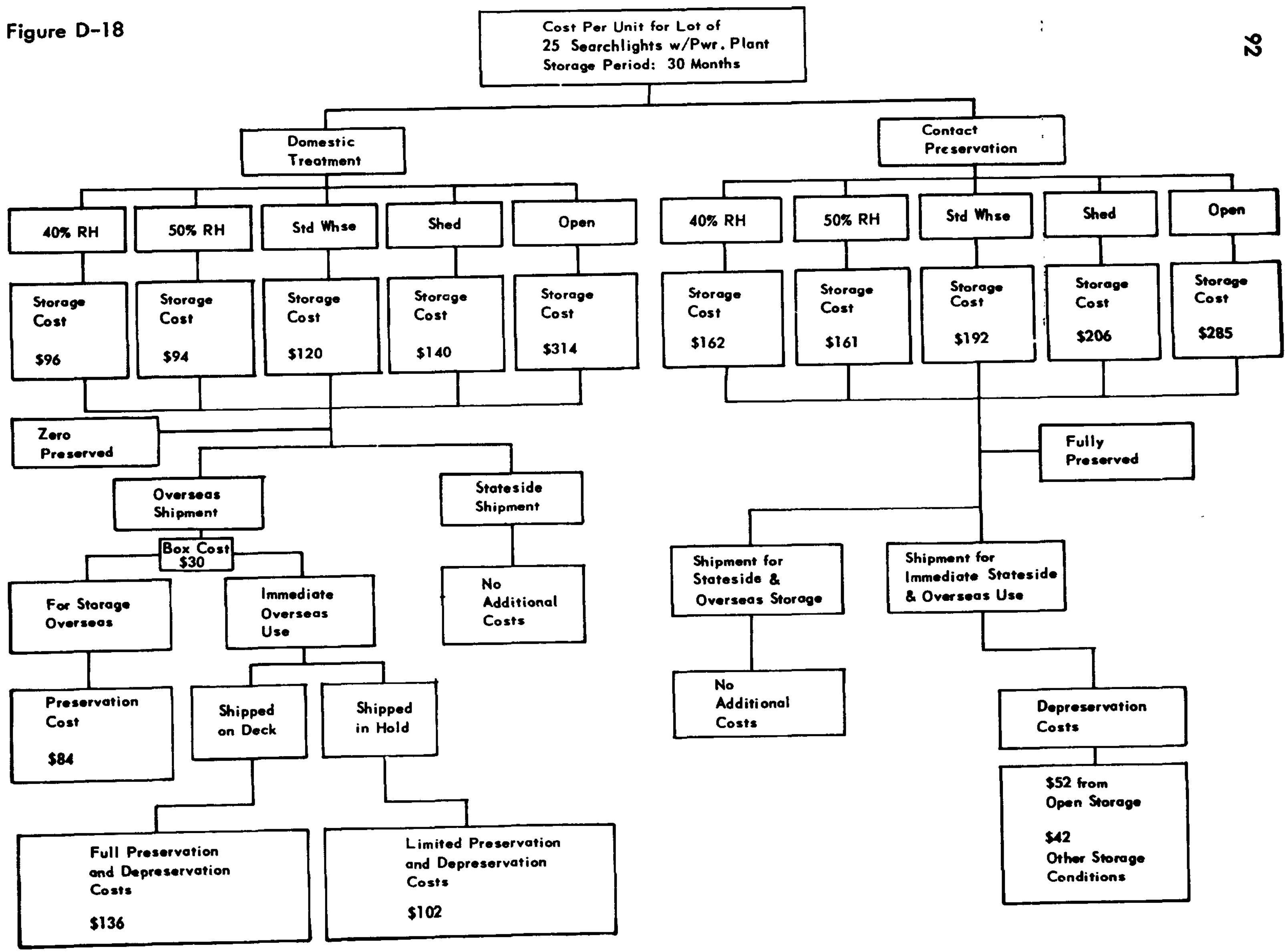
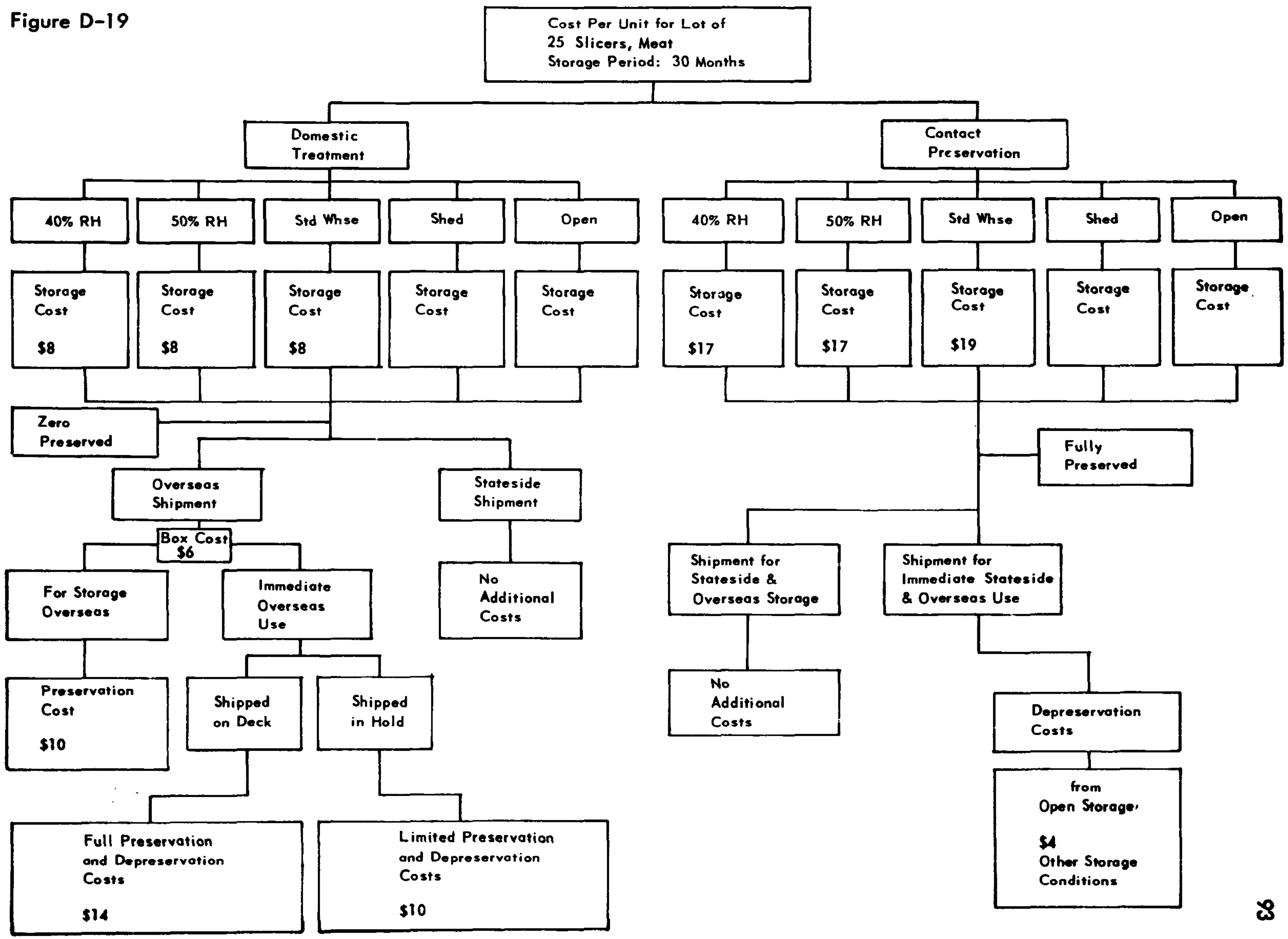

Cost Per Unit for Lot of
25 Searchlights w/Pwr. Plant
Storage Period: 30 Months
Domestic Treatment
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $96
Storage Cost $94
Storage Cost $120
Storage Cost $140
Storage Cost $314
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $30
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $84
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $136
Limited Preservation and Depreservation Costs $102
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $162
Storage Cost $161
Storage Cost $192
Storage Cost $206
Storage Cost $285
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$52 from Open Storage
$42 Other Storage Conditions

Figure D-19



Cost Per Unit for Lot of
25 Slicers, Meat
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $8
Storage Cost $8
Storage Cost $8
Storage Cost
Storage Cost
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $17
Storage Cost $17
Storage Cost $19
Storage Cost
Storage Cost
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $6
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $10
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $14
Limited Preservation and Depreservation Costs $10
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
from Open Storage, $4
Other Storage Conditions

Figure D-20

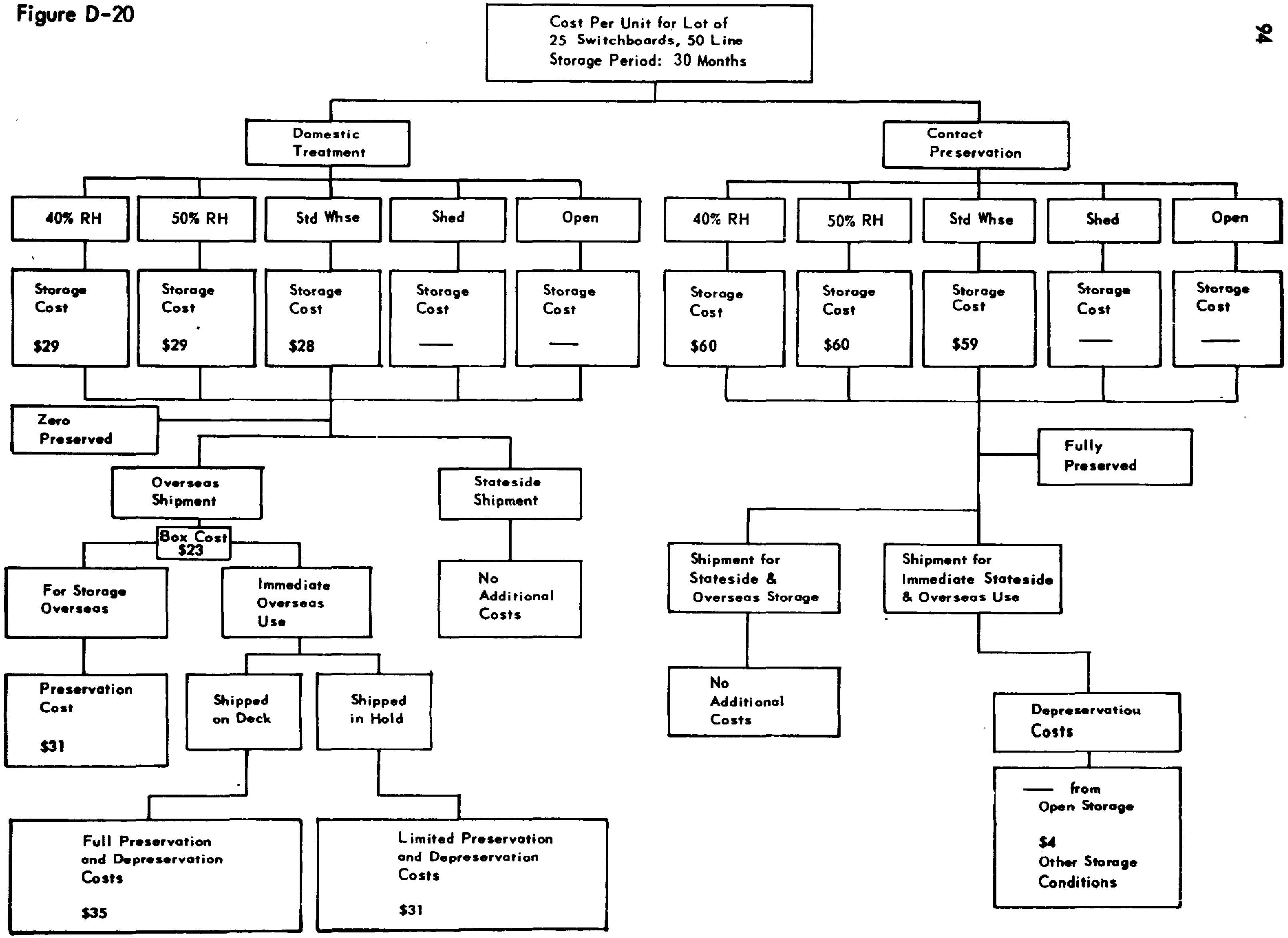

Cost Per Unit for Lot of
25 Switchboards, 50 Line
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $29
Storage Cost $29
Storage Cost $28
Storage Cost —
Storage Cost —
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $60
Storage Cost $60
Storage Cost $59
Storage Cost —
Storage Cost —
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $23
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $31
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $35
Limited Preservation and Depreservation Costs $31
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
— from Open Storage
$4 Other Storage Conditions

Figure D-21

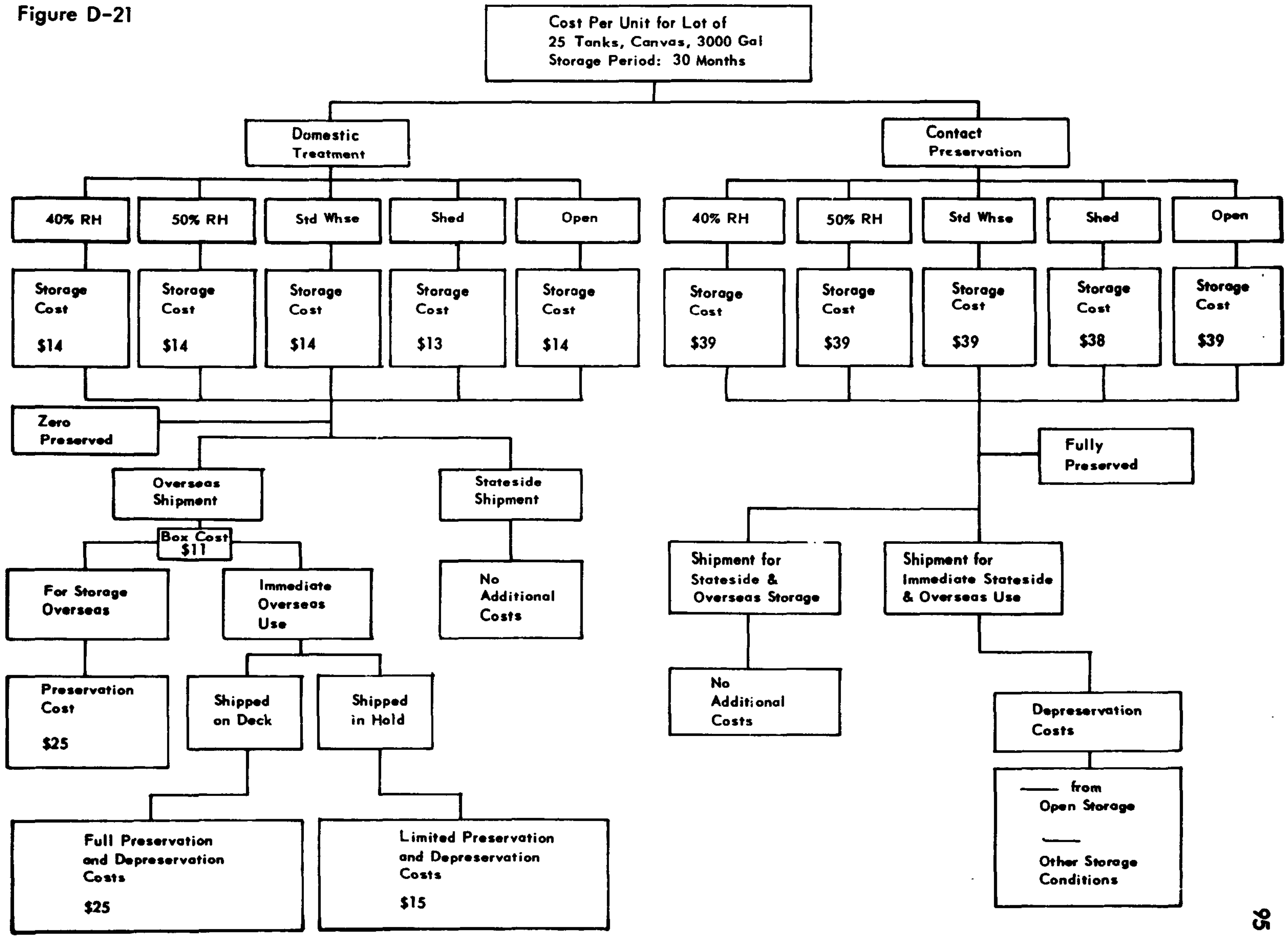

Cost Per Unit for Lot of
25 Tanks, Canvas, 3000 Gal
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $14
Storage Cost $14
Storage Cost $14
Storage Cost $13
Storage Cost $14
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $39
Storage Cost $39
Storage Cost $39
Storage Cost $38
Storage Cost $39
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $11
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $25
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $25
Limited Preservation and Depreservation Costs $15
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
from Open Storage
Other Storage Conditions

Figure D-22

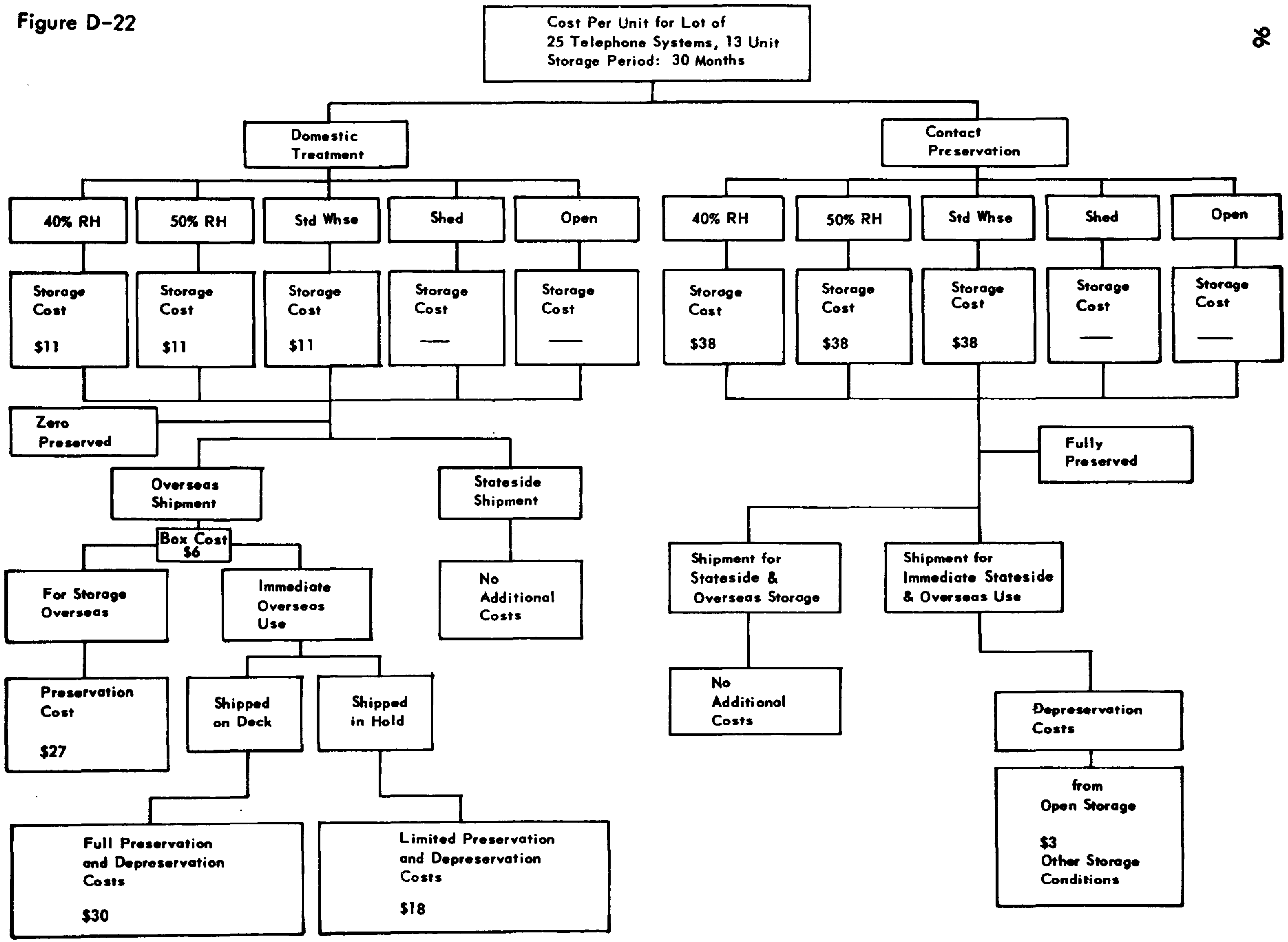
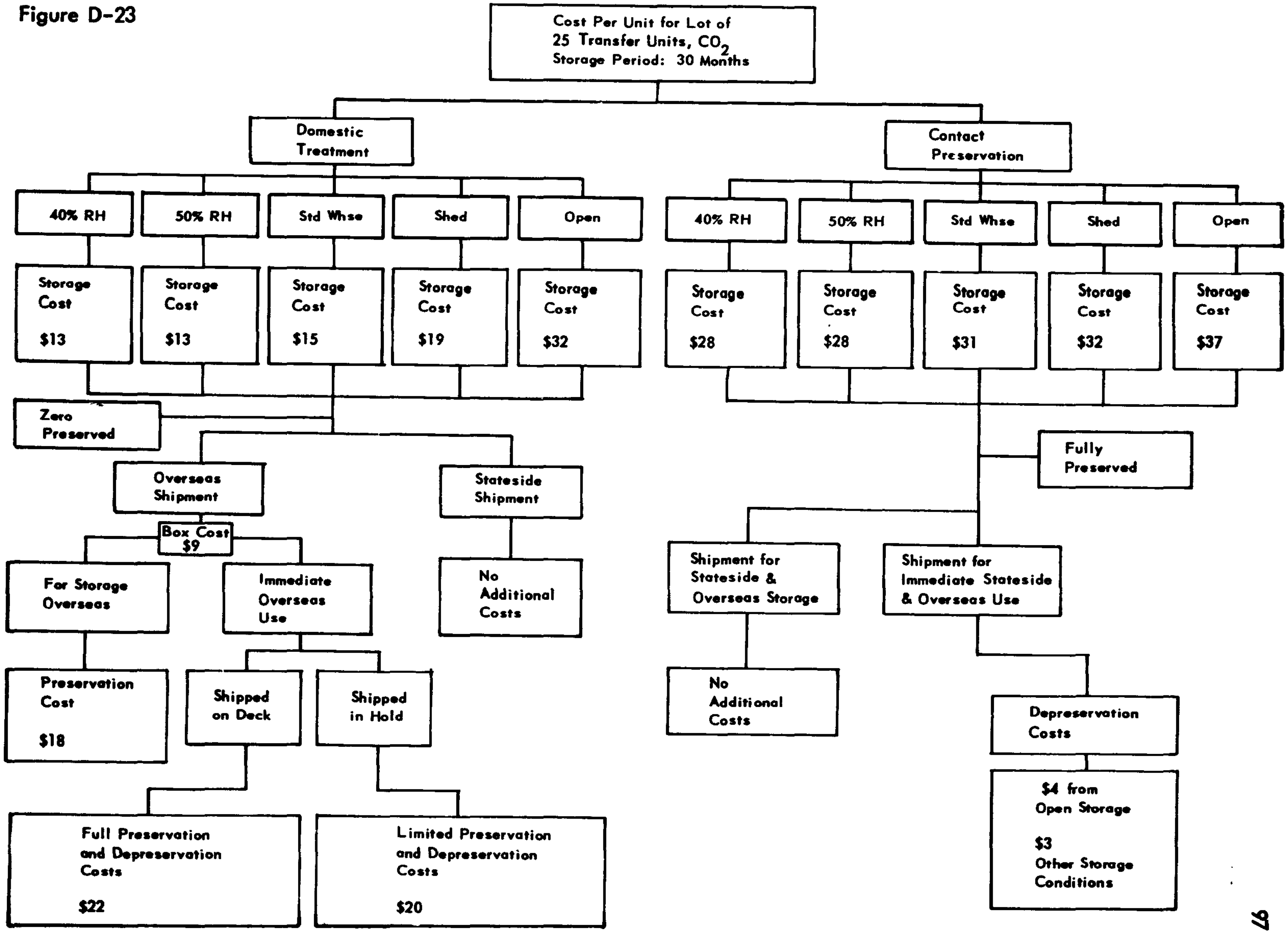

Cost Per Unit for Lot of
25 Telephone Systems, 13 Unit
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $11
Storage Cost $11
Storage Cost $11
Storage Cost —
Storage Cost —
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $38
Storage Cost $38
Storage Cost $38
Storage Cost —
Storage Cost —
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $6
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $27
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $30
Limited Preservation and Depreservation Costs $18
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
from Open Storage
$3
Other Storage Conditions

Figure D-23



Cost Per Unit for Lot of 25 Transfer Units, CO_2 Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $13
Storage Cost $13
Storage Cost $15
Storage Cost $19
Storage Cost $32
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $28
Storage Cost $28
Storage Cost $31
Storage Cost $32
Storage Cost $37
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $9
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $18
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $22
Limited Preservation and Depreservation Costs $20
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$4 from Open Storage
$3 Other Storage Conditions

Figure D-24

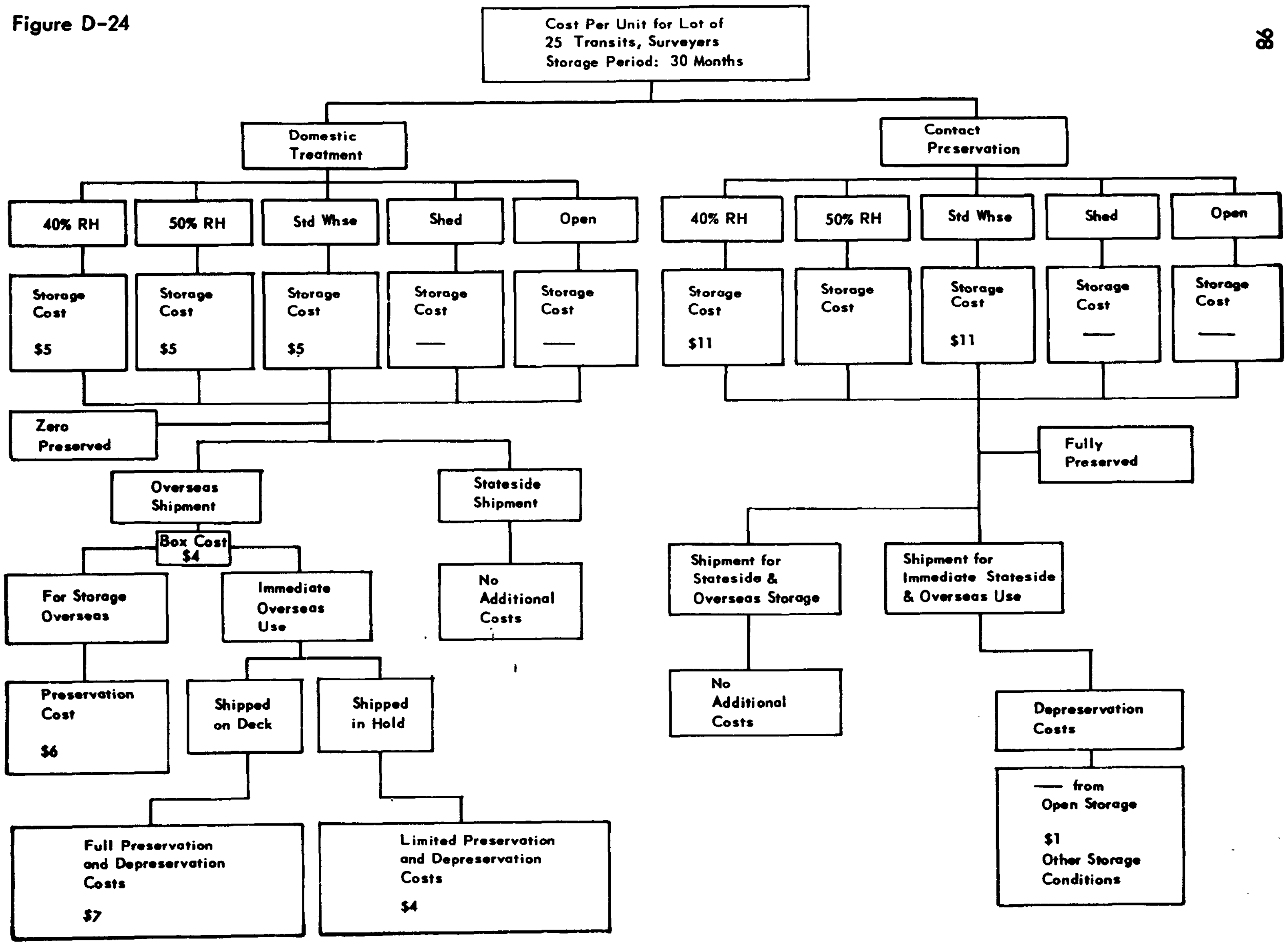

Cost Per Unit for Lot of 25 Transits, Surveyers Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $5
Storage Cost $5
Storage Cost $5
Storage Cost —
Storage Cost —
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $11
Storage Cost
Storage Cost $11
Storage Cost —
Storage Cost —
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $4
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $6
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $7
Limited Preservation and Depreservation Costs $4
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
— from Open Storage
$1 Other Storage Conditions

Figure D-25

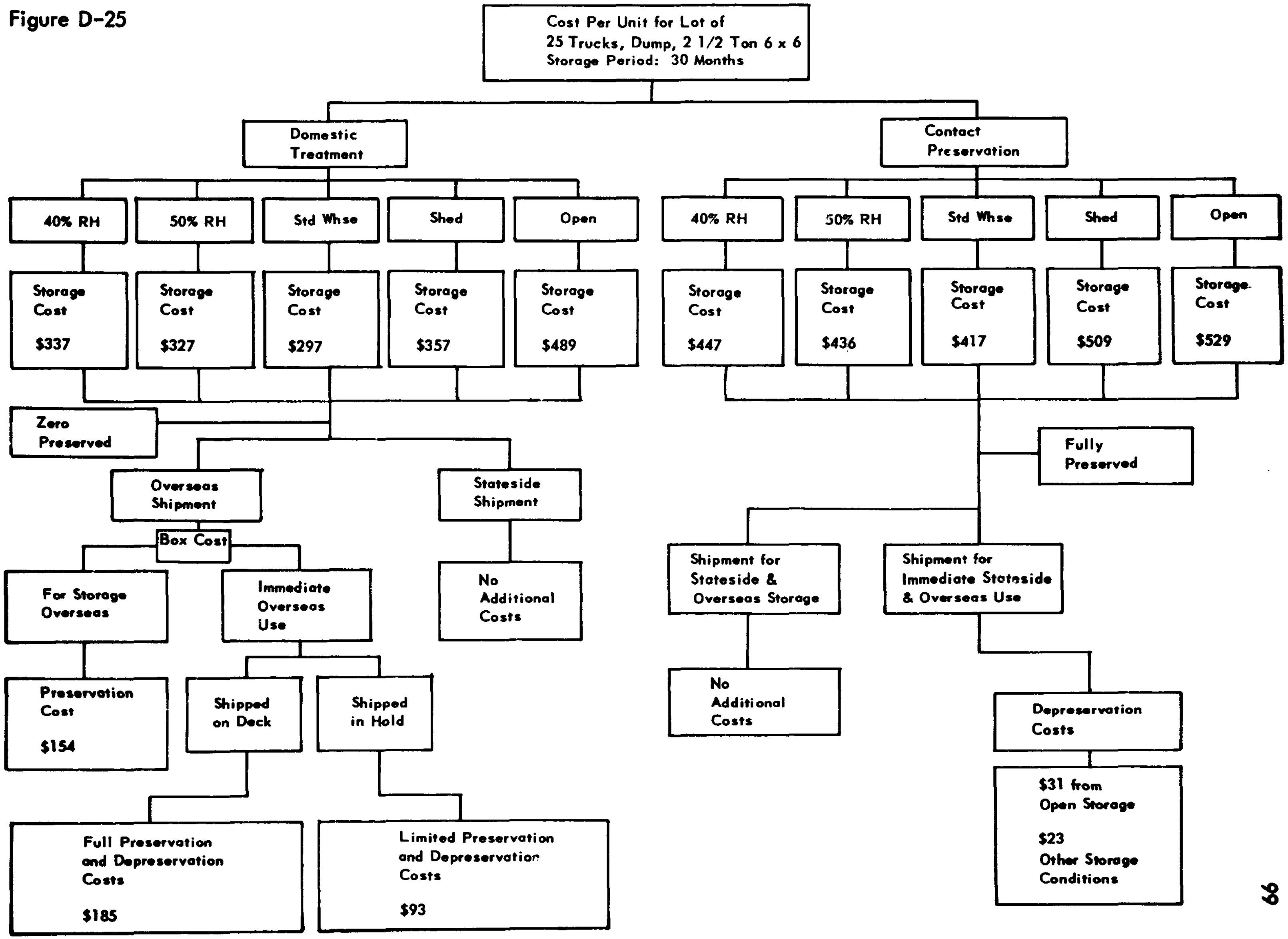

Cost Per Unit for Lot of
25 Trucks, Dump, 2 1/2 Ton 6 x 6
Storage Period: 30 Months
Domestic Treatment
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $337
Storage Cost $327
Storage Cost $297
Storage Cost $357
Storage Cost $489
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $447
Storage Cost $436
Storage Cost $417
Storage Cost $509
Storage Cost $529
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $154
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $185
Limited Preservation and Depreservation Costs $93
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$31 from Open Storage
$23 Other Storage Conditions

Figure D-26

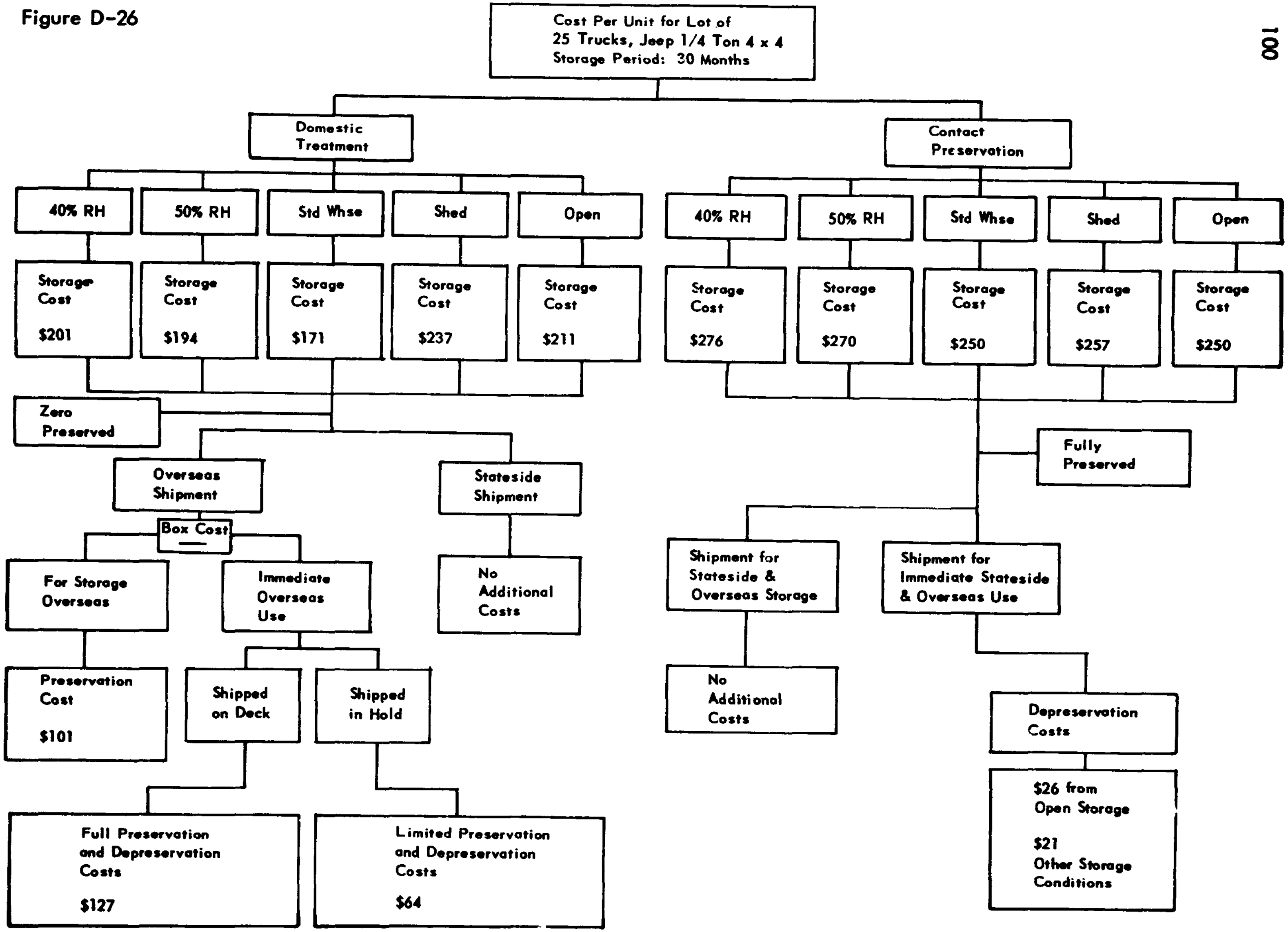
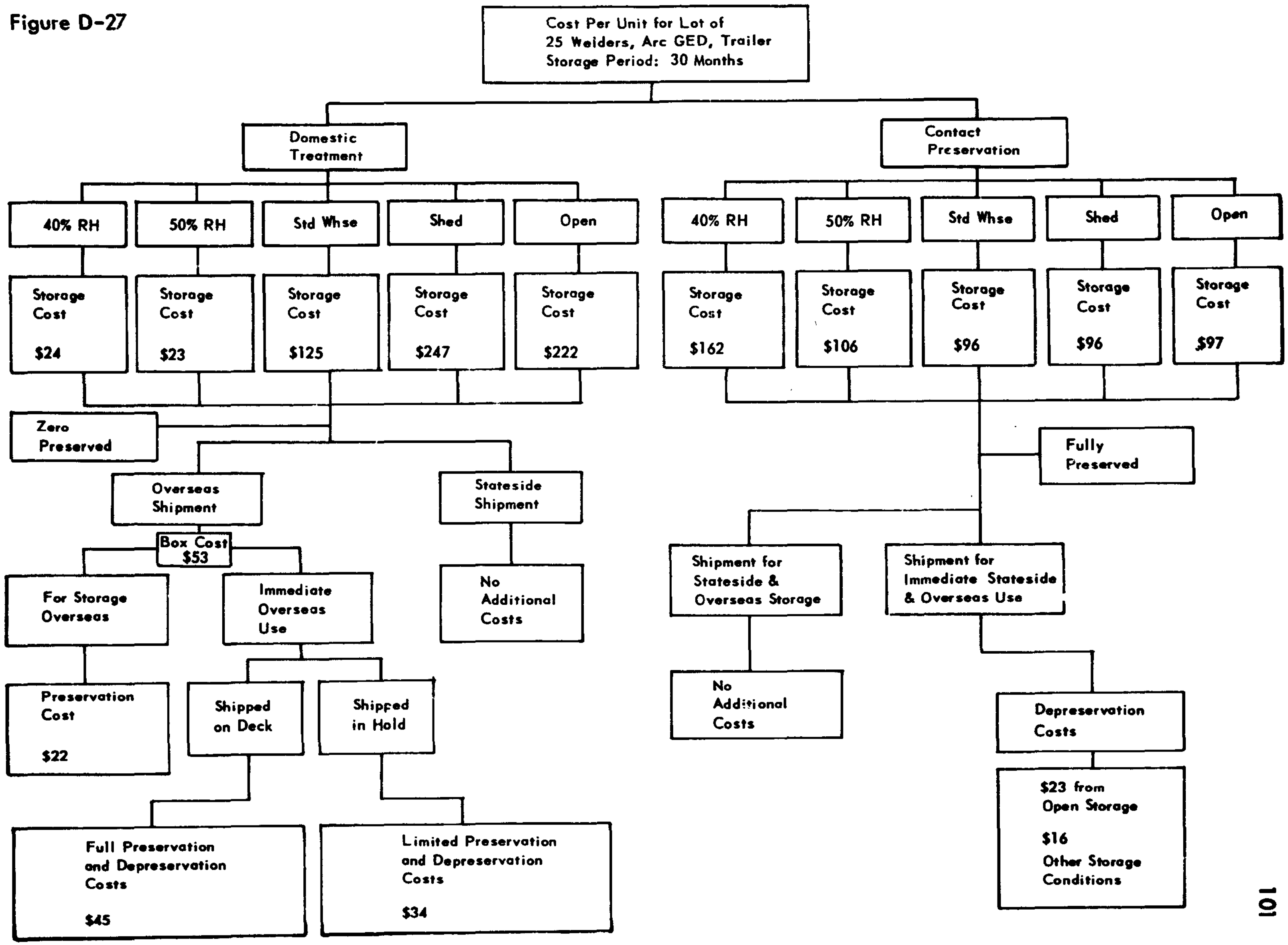

Cost Per Unit for Lot of
25 Trucks, Jeep 1/4 Ton 4 x 4
Storage Period: 30 Months
Domestic Treatment
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $201
Storage Cost $194
Storage Cost $171
Storage Cost $237
Storage Cost $211
Zero Preserved
Overseas Shipment
Box Cost
Stateside Shipment
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $101
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $127
Limited Preservation and Depreservation Costs $64
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $276
Storage Cost $270
Storage Cost $250
Storage Cost $257
Storage Cost $250
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$26 from Open Storage
$21 Other Storage Conditions

Figure D-27



Cost Per Unit for Lot of 25 Welders, Arc GED, Trailer Storage Period: 30 Months
Domestic Treatment
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $24
Storage Cost $23
Storage Cost $125
Storage Cost $247
Storage Cost $222
Zero Preserved
Overseas Shipment
Stateside Shipment
Box Cost $53
For Storage Overseas
Immediate Overseas Use
No Additional Costs
Preservation Cost $22
Shipped on Deck
Shipped in Hold
Full Preservation and Depreservation Costs $45
Limited Preservation and Depreservation Costs $34
Contact Preservation
40% RH
50% RH
Std Whse
Shed
Open
Storage Cost $162
Storage Cost $106
Storage Cost $96
Storage Cost $96
Storage Cost $97
Fully Preserved
Shipment for Stateside & Overseas Storage
Shipment for Immediate Stateside & Overseas Use
No Additional Costs
Depreservation Costs
$23 from Open Storage
$16 Other Storage Conditions

APPENDIX E

STORAGE ENVIRONMENT ERECTION COSTS

The following itemized list of costs associated with the erection of storage environments is based on 1955 material prices and labor rates.

OPEN AIR

Site Preparation	$ 500
Foundation & slab (40 ft x 100 ft)	2500
Total	$3000

Amortization period is 10 years

SHED

Prefabricated metal building (40 ft x 100 ft)	$4770
Site preparation	500
Foundation and slab	3500
Building erection	2200
Electrical	1000
Exterior painting	1000
Total	$12,970

Amortization period is 25 years

STANDARD WAREHOUSE

Prefabricated metal building (40 ft x 100 ft)	$4770
Site preparation	500
Foundation and slab	3500
Building erection	2600
Electrical	1000
Insulating	1410
Exterior painting	1000
Total	$14,780

Amortization period is 25 years

CONTROLLED HUMIDITY WAREHOUSES

Prefabricated metal building (40 ft x 100 ft)	$4770
Site preparation	500
Foundation and slab	3500
Building erection	2600
Sealing	600
Electrical	1000
Insulating	1410
Desiccant equipment	1550
Exterior painting	1000
Total	$16,930

Amortization period is 25 years

APPENDIX F

ESTIMATED COST OF PACKING (BOXES & CRATES) FOR STORAGE

Description	SNS No.	Estimated Cost	
		Domestic	Contact
Boiler, vertical 180,000 BTU	4520-184-3708	$16	$27
Chemical Warfare Detector Kit	6665-L60-0123	2	2
Compressor Set 30 CFM	4310-L60-0089	19	31
Distillation Unit 83 GPH	4620-185-0857	20	33
Drill Press, 18 inch Swing, Canedy	3413-L60-0001	19	19
Fan, Exhaust 4900 CFM	YS66-F-70020-50	15	15
Floodlight Trailer Mobile	6230-283-9760	Uncrated	Uncrated
Generator Set 30 KW Diesel	6115-295-0973	38	63
Heater, Oil fired 50,000 BTU	4520-200-0647	23	23
Lathe, floor model 14-1/2 inch swing	3416-174-1535	37	37
Machine, Washing Prosperity	3510-240-6552	38	38
Oven, Bake (Viking V-10-434)	7310-275-6180	35	35

Description	SNS No.	Domestic Estimated Cost	Contact Estimated Cost
Public Address System	5830-501-4724	$45	$45
Pump, Centrifugal 350 GPM	4320-273-8574	28	46
Pump, Diaphragm 3000 GPH	4320-132-5382	19	33
Refrigeration Panels F/6800 Unit Pkg #3	4110-287-3179	49	89
Refrigerator Unit 675-6800	4110-287-3184	32	54
Saw, radial 16 inch	YL40-S-1365-200	34	34
Searchlight 60 inch w/GE Power Plant	6230-L60-0142	30	30
Slicer, Meat, Hobart Mod. 411	7320-222-417	6	6
Switch Bd, 50 Line, Stromberg-Carlson	5805-501-4725	23	23
Tank, Canvas, 3000 gal.	5430-222-1923	11	11
Telephone System, 13-unit Distograph	5805-501-4726	6	6
Tires 8.25 x 20 10 Ply 1954	Y8-T-9076	Uncrated	Uncrated
Transfer Unit, CO_2	3655-245-0073	9	9

Description	SNS No.	Domestic	Contact
		Estimated Cost	
Transit, Surveyor's	YZ18-T-3311-750	$ 4	$ 4
Truck, Dump 2-1/2 ton 6 x 6	2320-835-8595	Uncrated	Uncrated
Truck, Jeep 1/4 ton 4 x 4	2320-835-8317	Uncrated	Uncrated
Welder, Arc GED Trailer, 300 AMP	3432-224-7722	53	53

APPENDIX G

92/jd
Serial 5429
22 Dec 59

From: Commanding Officer, U. S. Naval Construction Battalion Center, Port Hueneme, California
To: Commanding Officer and Director, U. S. Naval Civil Engineering Laboratory, Port Hueneme, California

Subj: Storage cost data; verification of

Ref: (a) NCEL ltr ser 2389 of 4 Dec 59 to CBC PorHue

1. As requested in reference (a) this Center reviewed the costs supplied to NCEL and found them substantially correct. It must be recognized that a portion of the figures supplied were estimates, by necessity, as work of the type requested is not being performed by this Center. In addition, actual test cost figures were revised to be indicative of normal operations instead of those actually performed during the tests due to the fact that some mechanic's time was lost through delays in photography, special handling, etc. These delays were not reflected on the original Work Order records of the tests. Therefore, in order to avoid distorted cost figures, estimated corrections were applied to the cost figures prior to submittal to NCEL.

2. It has been noted that the present application of the cost figures in the NCEL Cost Formula is divergent from not only the CBC mission but normal operating procedure at this Center. The purpose of the Quality Control program at this Center as outlined in TP-QC-1 is to provide at all times, a maximum assurance of readiness and reliability of materiel stocks, and to assure that such stocks are maintained at all times in serviceable and ready for issue condition. To this end inspection and preservation procedures are followed which minimize the possibility of equipment deterioration between normal inspection cycles. In addition, any deficiencies discovered are repaired upon detection or as soon as possible thereafter. Three areas of divergence are:

a. The NCEL test procedure which was followed and the present application of the NCEL Storage Cost Formula are such that repairs are not performed to the equipment when deficiencies develop, but are deferred to the time when the storage tests are completed. A functional relationship of repair cost versus months in storage is then used in the cost formula.

92/jd
Serial 5429
22 Dec 59

The main area of deviation evident in the formula usage is the fact that these repairs were not made when the deficiencies were first discovered. In the case of domestically treated materiel, rejections of various components of the equipment on different inspections would have necessitated repair of all items of the lots two and three times in many cases during the storage period. This consideration can completely change the results of the cost comparison between domestic and contact preserved items.

b. A major portion of the Prime Mission of this Center is the maintenance of Mobilization Reserve Stock in proper operating condition and to ship this equipment to Advance Bases according to planned Naval Operations during initial phases of an emergency. Heavy shipments are required during the first ten (10) days of specific emergencies, along with continued large movements for several months thereafter. The ability of this Center to carry out these requirements is based on minimizing the amount of manhours necessary to prepare this equipment for shipment. Items which are preserved Level C (Domestic Pack) do not meet the requirements for preservation, packing, or packaging of materiel to meet military operations except in a minor number of instances. (See ONM Instructions 4030.1A). If the present Service equipment was stored with Domestic treatment, this Center would not have the capabilities of meeting the shipping requirements for the equipment in the event of emergency Naval operations, due to the extremely heavy work-load in preservation, packing, and packaging. Thus any evaluation of costs for Domestic preservation versus Contact preservation must consider the shipping requirements in relation to manpower availability at the storage site.

c. Another less important aspect is the use of modified preservation treatment on the automotive equipment now being stored in either Standard Warehouses or Dehumidified Warehouses at this Center. These modified levels considerably reduce the cost of processing and handling the equipment and are used for 90% of the Automotive equipment now being processed into storage. Since the NCEL test data on automotive equipment is based on Long Term contact preservation no direct comparison with Standard operating procedure can be made.

3. As a result of the above considerations, it is recommended that the use of cost figures as supplied by this Center be restricted to the test evaluation and not projected into studies beyond the scope of the actual tests - which is the evaluation of storage environments - unless these factors of divergence are emphasized in the report.

C. E. SPELLMAN